THE PROFESSIONAL PRACTICE OF
ARCHITECTURAL WORKING DRAWINGS

OSAMU A. WAKITA · NAGY R. BAKHOUM · RICHARD M. LINDE

FIFTH EDITION

WILEY

TABLE OF CONTENTS

List of Tables

List of Illustrations

Chapter 10

Chapter 14

The Professional Practice of Architectural Working Drawings

FIFTH EDITION

Osamu A. Wakita

Nagy R. Bakhoum

Richard M. Linde

WILEY

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.

Published simultaneously in Canada.

Library of Congress Cataloging*_*in*_*Publication Data:

Names: Wakita, Osamu A., author. | Bakhoum, Nagy R., author. | Linde, Richard M., author.

Title: The professional practice of architectural working drawings / Osamu A. Wakita, Nagy R. Bakhoum, Richard M. Linde.

Description: Fifth edition. | Hoboken : Wiley, 2017. | Includes index.

Identifiers: LCCN 2016058964 (print) | LCCN 2016059766 (ebook) | ISBN 9781118880524 (hardback) | ISBN 9781118880555 (pdf) | ISBN 9781118880852 (epub)

Subjects: LCSH: Architecture—Designs and plans—Working drawings. | BISAC: ARCHITECTURE / Design, Drafting, Drawing & Presentation.

Classification: LCC NA2713 .W34 2017 (print) | LCC NA2713 (ebook) | DDC 720.28/4—dc23

LC record available at https://lccn.loc.gov/2016058964

Cover Design: Wiley

Cover Image: Osamu A. Wakita

This book is dedicated to our families, to students of architecture, and to the memory of Richard Linde, Jakob Wakita, and Baido (Giichi) and Nobue Wakita.

PREFACE

The purpose of this book is to teach techniques; attitudes; computer…aided drafting (CAD); building information modeling (BIM) and Revit, the computer program that makes it possible, as well as the fundamental concepts of architectural working drawings. With the introduction of BIM and Revit, the profession has changed radically, as has the education of architectural drafters. In the past, employees concentrated on CAD; now we must return our focus to architecture. BIM requires our new legions of designers, drafters, and architects to know more about the process of architecture and building components than ever before. The profession of architecture has changed from 20% design and 80% working drawings to 80% constructing a three…dimensional (3…D) model and 20% working drawings. With Revit, when the design development phase of a project is complete, the working drawings are all but complete as well. The projects become front loaded and require a person working in the parametric data of 3…D modeling to have full knowledge of structure, engineering, design, and site grading, to mention just a few of the necessary areas. There is a new approach to the process of creating working drawings: that of a fully parametric system where the software is integrated to aid in the process of drafting. The focus of developing drawings is shifted from the computer to the individual.

Every chapter has been revised with current information. The text is intended to strongly encourage drafters to go beyond the two…dimensional AutoCAD system and start thinking in 3…D, even if they still work in 2…D. It is both critical and essential to move out of your comfort zone to explore the programs that offer a more cohesive system of drafting, namely Revit. Within these chapters, you will find the method required to produce working drawings to a national standard.

The Professional Practice of Architectural Working Drawings, 5th edition, has three divisions. Part I, “Professional Foundations,” consists of Chapters 1 through 6 and is designed to introduce such topics as Leadership in Energy and Environmental Design (LEED), BIM, Revit, and green and sustainable architecture. The first third of the book thus investigates the field of architecture and takes a close look at how offices work.

Part II, “Document Evolution,” which includes Chapters 7 through 13, reflects the attitudes and concerns covered in Part I, while establishing a professional approach toward the national standards for architectural drawings. It also covers how to communicate the architect's ideas into a series of dialogues among the architect, client, and contractor. Architectural words are defined as they are introduced in the text. An integration of chapters was developed to educate our pre…architectural pupil/readers to think three dimensionally, so that the process becomes a reality.

Part III, “Case Studies,” includes two new case studies completed in AutoCAD, intended to further demonstrate working drawings for both a one…story and a two…story wood…framed residence. Drawings are broken down from the fundamental stages to completion. Two additional chapters exemplify the drawings of more complex commercial buildings for study, but are developed with the use of BIM as implemented by Revit. Last is a

commercial tenant improvement project, which exemplifies a typical build…out of an established architectural space, such as a storefront or high…rise building.

As educators, we recognize the need to create a document for the future challenge, giving our students a greater depth of understanding. If a prospective or new employee has good prior knowledge of the inner workings of architecture, an office will be able to teach technique in a short period of time. To that end, every chapter has been rewritten and reorganized to include a wealth of information on how drawings must be performed. All this is done with an eye toward how people learn. Education and architecture can and must be done in the same manner. It is imperative to perceive architecture holistically—as more than its parts—because the whole is indeed greater than the sum of its parts.

ACKNOWLEDGMENTS

Tony Micu, AIA, president of the South Bay Chapter of the AIA, for kick…starting our move toward BIM and Revit.

Cynthia Wakita, for her timeless and unceasing research and permissions work.

Natalie K. Bakhoum, for her unwavering support in this new venture.

Sally Keim Wakita, wife and spirit behind this text and also proofreading the book.

Marilyn Salazar, caregiver for Osamu Wakita and often participant as a typist.

Michael Villegas, having taught computer technology and Revit over some 26 years, validated the manuscript with his knowledge in this area.

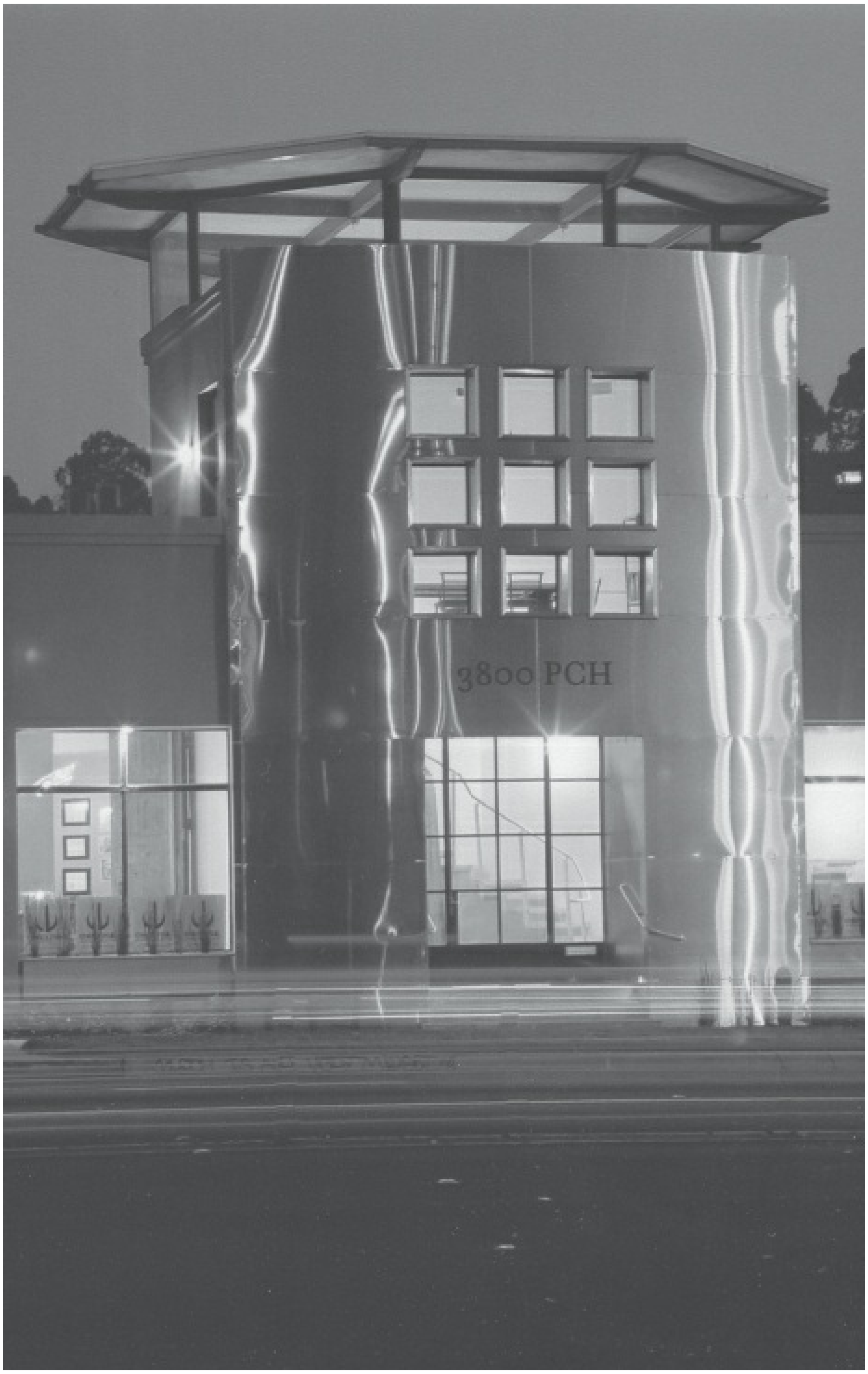
Margaret Cummins, fifth…edition senior editor, for her help in guiding us through yet another edition.

Lauren Olesky, for providing technical information in response from Wiley.

PART I
Professional Foundations

The information contained in Chapters 1 through 6 is intended to establish the fundamentals for those practicing in the field of architecture. These chapters will shape your understanding of an office, the practice, the stages, and the drawings of architecture. The concept of a good foundation applies to both structures and individuals: without a solid foundation, failure is imminent. On this basis, the groundwork for architecture—the office and specific aspects of working drawings, an important component of construction documents—will be the backbone on which these chapters are founded.

Chapter 1
PROFESSIONAL FOUNDATIONS



THE PHYSICAL OFFICE

The physical plant of the architectural office has begun to take on a new look. The firm that once worked only in a local community now has a global reach. Where proximity once limited the opportunity for a client to access global talent, the computer, transportation, and communications technology allow for interviews based on architectural ability rather than proximity. It is no longer necessary to select an architect in one's immediate community because technology allows for virtual meetings around

the globe.

It is not one firm but many that may construct drawings in a collaborative effort based on the ebb and flow of the size of the project. The result is that any firm of any size can join another to achieve an assigned task. Today, *network* does more than just describe a system of communication; it also describes the architect's role. An individual may work on a drawing halfway around the world, while at the project location it is the middle of the night. **Redlines**, or corrected drawings, can be marked up electronically and dropped in cloud servers for the next work shift, resulting in two times the production in the normal time. An architecture firm that specializes in design can partner with another firm that specializes in construction documents and utilize the strengths of each firm.

Architecture is a small crafts industry in which most offices employ one to four people. A home office may also be part of the office structure. A single drafter may be hired by two or more firms, in which case the office becomes a docking station for electronic project information, such as construction documents. Because digital images can be rapidly moved electronically, one can send documents across the world instantly. In the traditional architectural firm, an architect in a firm leads the project and distributes the work among the staff within the firm. When a workload jam arises, the architect may hire a subcontractor to aid in development of the required drawings.

OFFICE STRUCTURE

The way in which an architectural firm is structured and the office practices it employs depend on the magnitude and type of its projects, the number of personnel, and the philosophies the architects hold with regard to office practice procedures. Normally, the architect or architects are the owners and/or principals of the practice.

The architectural firm can be established as a sole proprietorship, partnership, or several options of corporations. When first establishing a firm, the principal of the firm must determine how to operate the business of architecture. The simplest of these is a **sole proprietorship**. This is not an ideal system for a large firm, but it may be ideal for a small firm that has a single owner that will file the income as part of the personal income tax. This does not preclude the firm from hiring employees but it does limit the ability to have partners and does not easily separate personal assets from company assets. A **partnership** is where two or more people share the ownership of the company. These partners do not have to own equal shares of the company, and they share the profits based on the percentage of the ownership in the firm. Liability is similar to that of the sole proprietor but you must choose your partner well, as their good or bad decisions will directly affect your bottom line. **Corporations** require at least two stockholders but could have hundreds of stockholders. While a corporation is the most complex system to establish due to laws that govern corporations, it's ideal for separation of personal/corporate assets. Within the laws that govern corporations, there are a variety of corporation types to choose from: S corporation, C corporation, limited liability partnership (LLP), and limited liability corporation (LLC).

Although a small firm will differ from a medium, large, or extra…large firm, many of the functions will be the same. In all firms, a licensed architect will oversee staff as a direct supervisor. In each firm, services such as **programming** (determining the objectives of the project), **space planning** (the layout of the furnishings and fixtures), feasibility studies, site analysis, coordination, scheduling, and architectural design will be provided according to the firm's contract with the client. As a firm's size increases, one major factor does change: that of documentation of directives and communications. Of course, it is imperative for a firm of any size to track its work and communications with clients. However, as the firm size increases, the documentation becomes critical; as larger project teams mobilize to perform tasks, any lack of documentation can result in reworking projects and significant loss of revenue.

In general, an architectural office can be separated into three main departments: the administration department, the design department, and the production department. The principal or principals oversee all three departments in addition to their other duties.

Administration Department

The administration department handles all communications between the architectural firm and its clients on items such as contracts, fee schedules, billing for services, and similar matters. This department handles all secretarial duties, including all written correspondence, payment of operating costs, accounting procedures, paying salaries, marketing, and maintaining project records relating to individual project costs and procedures. This department may also handle **human resources (HR)** functions, including management of the firm's staff.

Under the purview of administration, many firms also include a marketing department. Tasks for this department might include development and maintenance of a web site, creation and dissemination of publication materials, assembly of competition entries, and development of promotional materials. Marketing is used to focus a firm on a particular area of work and take advantage of opportunities that may arise for a specific project type that the firm prefers or in which it specializes.

Design Department

The design department is normally headed by a principal architect and/or an associate architect. This person (or persons) meets with the client to determine the requirements of a project, the economics of the project, and the anticipated time frame for completing the construction documents. These initial concerns determine the program for the project. The head (or heads) of this department delegate various work phases of a project to other staff members. The number of staff members depends on the size of the practice and the magnitude of the projects. Staff members may be assigned to teams or groups in their area of expertise for specific projects. A team takes a project from the initial schematic design concept, through design development, to the completed construction drawings and specifications. These stages may include model building, renderings,

coordination among all consulting engineers to meet their individual job requirements, job billing, and reproduction responsibilities. The leader of a project and of the design team staff is designated the **project architect**. A project architect's responsibilities are to develop a “game plan” for a specific project, which will include:

1. Design studies, philosophy, and concept
2. Initial structural considerations
3. Exterior and interior materials
4. Municipality and building code requirements
5. Architectural committee reviews
6. Building equipment requirements, **Leadership in Energy and Environmental Design (LEED)**
7. Manufacturing resources
8. Selection of required consultants (soils/geology, structural, mechanical, etc.)
9. Planned man…hours, time sheets, and billing dates
10. Office standards, such as symbols, wall delineations, and other graphic depictions

Production Department

The production department, under the supervision of a project architect, prepares all the phases for a set of completed construction drawings. Working drawings may be produced by a senior drafter, intermediate drafter, or junior drafter under the supervision of a licensed architect. These staff members and the project architect or job captain work as a team to make the transition from the approved preliminary drawings to the completion and implementation of the working drawings. The transition from the approved preliminary drawings to the development of the working drawings is elaborated in Part II of this book. Other chapters provide step…by…step procedures on how different sections of the working drawings are developed: the site and grading plan, foundation plan, floor plan, building sections, exterior elevations, roof and framing plans, interior elevations, architectural details, and schedules. During the process and completion of the various sections, the project architect and/or job captain constantly reviews the drawings for clarity, accuracy, and craftsmanship of detailing, and ensures that the drawings reflect all required revisions. Drawings are either created with the use of a **computer_aided drafting (CAD)** system, **building information modeling (BIM)**, or drawn manually using conventional instruments. A suggested organizational chart for the practice of architecture is depicted in Figure 1.1.

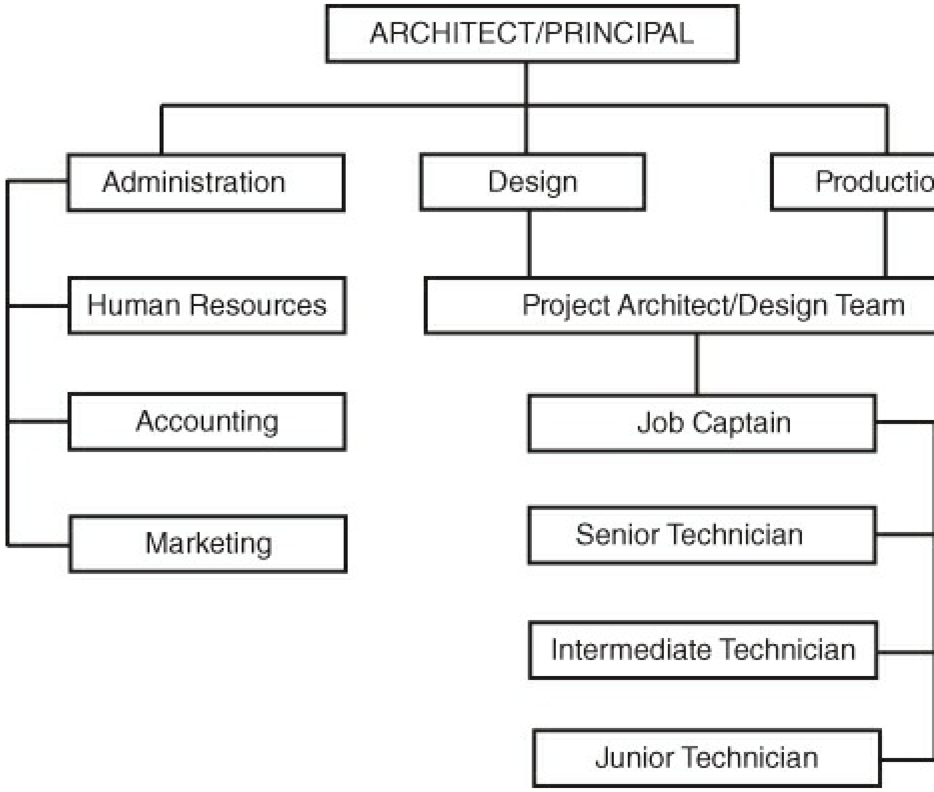


Figure 1.1 Suggested office organizational chart.

The Architect

An *architect* is an individual licensed by the state in which he or she practices architecture. An architect can be licensed in multiple states and practice from multiple offices. In most cases, the architect has a college education consisting of an undergraduate four… or five…year degree or a six… to seven…year graduate program at an accredited university. For a university to become accredited, the **National Architectural Accrediting Board (NAAB)** must certify that university for its merit in education. In addition to the formal education, a three…year **apprenticeship** or on…the…job training by skilled practitioners in the field is required. In some situations, an **internship** (experience in an architectural office during one's course of education) may also be counted toward the apprenticeship period. The **Architecture Registration Examination (ARE)**—testing that rivals the bar exam for lawyers in difficulty—must be taken after completion of one's education; the ARE is administered by the **National Council of Architectural Registration Boards (NCARB)**. Programs such as the **Intern Development Program (IDP)** are instrumental in aiding candidates for licensing, because they allow candidates to obtain experience in the diverse areas that are required to run and supervise an architectural firm. Once a license is obtained, the holder is required to pursue continuing education.

While it is possible to receive an architectural license without a formal education, it is very difficult and requires eight years of direct supervision from a licensed architect or a combination of architect, engineer, and contractor. On…the…job training is an important aspect of education, and in conjunction with the IDP program and passing the ARE, one can be a licensed architect.

RESOURCE LIBRARY

To find and detail all the equipment that is required for a structure (plumbing, hardware, finishes, etc.), it is necessary to have access to the various manufacturing resources for specific products. The most widely used product information source is the Internet. Electronic access allows architects and engineers to survey the resources available and select the equipment that will best enable the function of a building. Such equipment may be available from a myriad of different manufacturers, and range from conveying systems to windows, doors, and the like. Samples can be included in a firm's in…house library. Most of the literature found in electronic form is based on the **MasterFormat**, an organizational system widely used in the construction industry. These particular systems use the major divisions shown in Figure 1.2.

MasterFormat Groups, Subgroups, and Divisions

PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP

Division 00 – Procurement and Contracting Requirements
- Introductory Information
- Procurement Requirements
- Contracting Requirements

SPECIFICATIONS GROUP

GENERAL REQUIREMENTS SUBGROUP

Division 01 – General Requirements

FACILITY CONSTRUCTION SUBGROUP

Division 02 – Existing Conditions
Division 03 – Concrete
Division 04 – Masonry
Division 05 – Metals
Division 06 – Wood, Plastics, and Composites
Division 07 – Thermal and Moisture Protection
Division 08 – Openings
Division 09 – Finishes
Division 10 – Specialties
Division 11 – Equipment
Division 12 – Furnishings
Division 13 – Special Construction
Division 14 – Conveying Equipment
Division 15 – Reserved for Future Expansion
Division 16 – Reserved for Future Expansion
Division 17 – Reserved for Future Expansion
Division 18 – Reserved for Future Expansion
Division 19 – Reserved for Future Expansion

FACILITY SERVICES SUBGROUP

Division 20 – Reserved for Future Expansion
Division 21 – Fire Suppression

Division 22 – Plumbing
Division 23 – Heating, Ventilating, and Air-Conditioning (HVAC)
Division 24 – Reserved for Future Expansion
Division 25 – Integrated Automation
Division 26 – Electrical
Division 27 – Communications
Division 28 – Electronic Safety and Security
Division 29 – Reserved for Future Expansion

SITE AND INFRASTRUCTURE SUBGROUP

Division 30 – Reserved for Future Expansion
Division 31 – Earthwork
Division 32 – Exterior Improvements
Division 33 – Utilities
Division 34 – Transportation
Division 35 – Waterway and Marine Construction
Division 36 – Reserved for Future Expansion
Division 37 – Reserved for Future Expansion
Division 38 – Reserved for Future Expansion
Division 39 – Reserved for Future Expansion

PROCESS EQUIPMENT SUBGROUP

Division 40 – Process Integration
Division 41 – Material Processing and Handling Equipment
Division 42 – Process Heating, Cooling, and Drying Equipment
Division 43 – Process Gas and Liquid Handling, Purification, and Storage Equipment
Division 44 – Pollution and Waste Control Equipment
Division 45 – Industry-Specific Manufacturing Equipment
Division 46 – Water and Wastewater Equipment
Division 47 – Reserved for Future Expansion
Division 48 – Electrical Power Generation
Division 49 – Reserved for Future Expansion

Figure 1.2 *MasterFormat* division numbers and titles.

South Union Street, Suite 100, Alexandria, VA 22314.)

A wealth of product information is available directly from manufacturers, in the form of brochures, pamphlets, catalogs, manuals, and hardbound books. Actual samples of their products may also be obtained. The information available may include:

1. Advantages of a particular product over others
2. How the system works or is assembled
3. Necessary engineering
4. Detailed drawings
5. Special design features
6. Colors, textures, and patterns
7. Safety tests
8. Dimensioning
9. Installation procedures

Adapt this information to your particular needs in your geographic location. Also, understand that a manufacturer's goal is to sell product, so verify from neutral sources that it will do what it states.

You are limited only by your ability to navigate through the vast sea of information available through the Internet and your ability to retrieve the information necessary to satisfy and enhance completion of the working drawings. Digital drawings can also be obtained, making it unnecessary to draw configurations for products such as window profiles, stair rails, and so on. As the process of BIM becomes more mainstream, perhaps one of the greatest advantages is the family of information provided by the manufacturer to promote its product. Always verify the accuracy and appropriateness of a detail before you adopt it as your own.

Retail sources such as major book publishers produce architectural reference books. Many art supply and drafting supply stores also carry reference materials. Public libraries may have a variety of professional reference materials, including books, journals, and trade magazines. Colleges and universities offering architecture courses usually have a wealth of architectural resource materials. An example of a highly technical resource is the *AIA Architectural Graphics Standards* published by John Wiley & Sons. This book is found in almost all architectural offices. In addition, the **American Institute of Architects (AIA)** publishes standards and guidelines for architects to utilize as well.

ARCHITECT/CLIENT RELATIONSHIP

Working Relationship

The relationship between the architect and the client will vary. In general, the

relationship for a specific building project and the responsibilities and procedures necessary to accomplish the goals of the project will be initiated with the selection of the architect. After the architect is selected, the architect and the client enter into a contract, which defines the services to be performed and the responsibilities of the architect and the client. The client can be an individual, couple, team, or board of individuals that give direction and goals for the development of the project. Many states require architects to use a written contract when providing professional services.

The form of the agreement will vary with the size of the project and the scope of services that the architect will provide. As you can imagine, the larger and more complex tasks require more dialogue or terms to address legal issues. A good contract can provide clarity and remind all parties of the responsibilities that are shared to complete the goals that are required and define scope that is outside the contract that would be considered added scope for added costs.

After the contractual agreement is signed and a retainer fee is received, the architect reviews the building site and confers with the client to determine the goals of the building project. After establishing the project goals, there will be meetings with the governing agencies, such as the planning department, the building department, and architectural committees. The primary goal of the architectural team at this point is to initiate the preliminary planning and design phases.

Most architectural contracts and agreements include provisions for the architect and the consulting engineers to observe construction of the project during the various building stages. It is a standard practice for the architects to visit the site, determine if the construction is progressing correctly, and report their findings.

Professional Organizations

Professional organizations can be an asset to the business performance and office functions of an architectural firm. The AIA is an example of a professional organization that will provide members with recommended documents, including client/architect contractual agreements, client/contractor agreements, and many others. The AIA also provides recommended guidelines relative to fee schedules and disbursements, construction documents, building specifications, and construction observation procedures and documentation.

Ethical procedures and office practice methods are recommended and defined as part of the many documents available from the AIA.

It is recommended that associate architects and employees at the various technical levels become involved with a professional organization for a number of reasons, but primarily to stay aware of current technical information and activities within the architectural profession. The AIA also offers programs and directions for those in an internship phase of their careers. Student associate member programs available through the AIA provide an overall view of the architectural profession.

Other professional organizations for students of architecture can be found through students' colleges and universities.

Schematic Design

The next step in the architect/client relationship is the architect's presentation of the **schematic design (SD)** for the project. In this phase, an architect consults with the client/owner to determine the project goals and requirements, often called the program. The program, or architectural program, is used to establish the required functions of the project. I will typically include an estimated square footage of all the areas required in the project goals. In the SD phase, an architect develops study drawings, images, and documents that demonstrate the concepts of the design in scale that can best demonstrate the spatial relationships. Often, a conceptual site plan and floor plan of the building areas are reviewed for the building orientation and the preservation of existing landscaping elements such as trees, topography, and other site conditions. Figure 1.3 shows an example of a conceptual site and building plan. The client for this project desires to build a three…bedroom residence. The site, which is located in a beach community, is a small property. The lot is located on a corner where side and front…yard setbacks use most of the lot area, and the garage must be additionally set back to allow for a driveway with visibility.

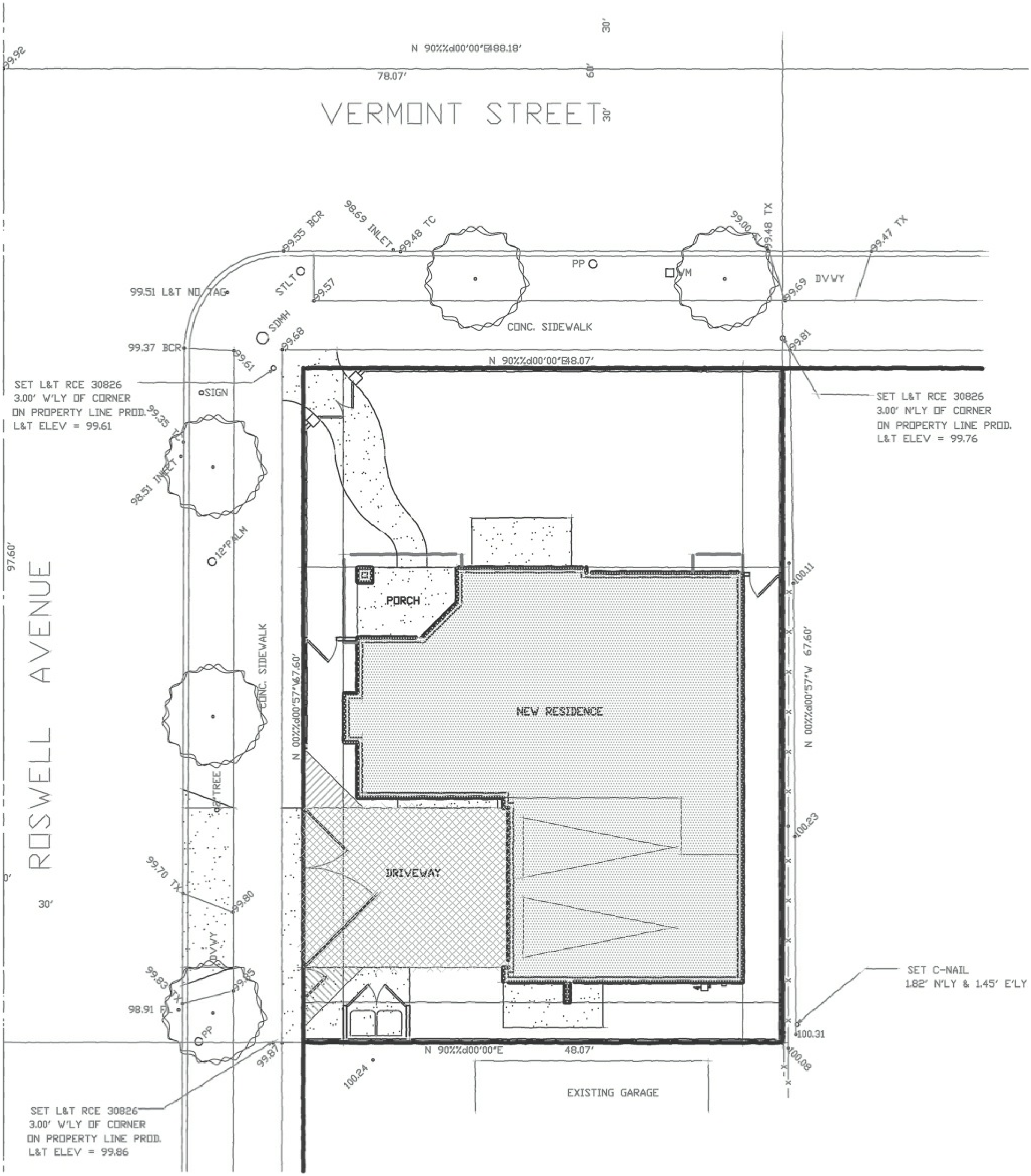


Figure 1.3 Schematic site design drawing.

(Courtesy of Nichole Shweiri.)

Schematic design also is the phase where research is done with respect to the jurisdictional departments. After the client's initial review of the planning and design for

the project, some revisions and alterations may be made to the design. In this case, the drawings are revised and presented again to the client for their approval. After the client approves the schematic design, the architect consults with and presents the schematic drawings to the various governing agencies, such as the planning department, for their review and comments. Any revisions and alterations that may be required by any of the agencies are executed and again reviewed by the client and approved. The schematic drawings are often used to estimate the initial construction costs, which are also submitted for client review and approval. Using BIM, it is possible to provide the client with a more accurate estimate of cost, because these programs incorporate the materials and methods of construction in the drafting process.

Wind direction, sun orientation, rainfall, flow of water on the site, and the most feasible automobile access to the site are considered (among other factors), and a schematic study is presented. From this initial schematic study, a preliminary floor plan is established, which shows the room orientations and their relationships to one another. Such a preliminary drawing is depicted in Figure 1.4. A second…floor…level preliminary plan is studied as it relates to the first…floor plan and the room orientation, as shown in Figure 1.5. Finally, a roof plan is designed to facilitate the use of a roof deck and roof garden; this preliminary study is illustrated in Figure 1.6. The studies of the exterior elevations evolved utilizing an asphalt shingle roof material, with a shallow pitched roof, and exterior walls of wood siding. After the client has approved the preliminary floor plans, the exterior elevations are presented to the client in preliminary form for approval and to the governmental agencies for their preliminary approvals. The north and west elevations are depicted in Figures 1.7 and 1.8. These preliminary drawings and designs are examples of the architect's studies that may be presented to a client for his or her approval prior to implementation of the design development and construction drawings.

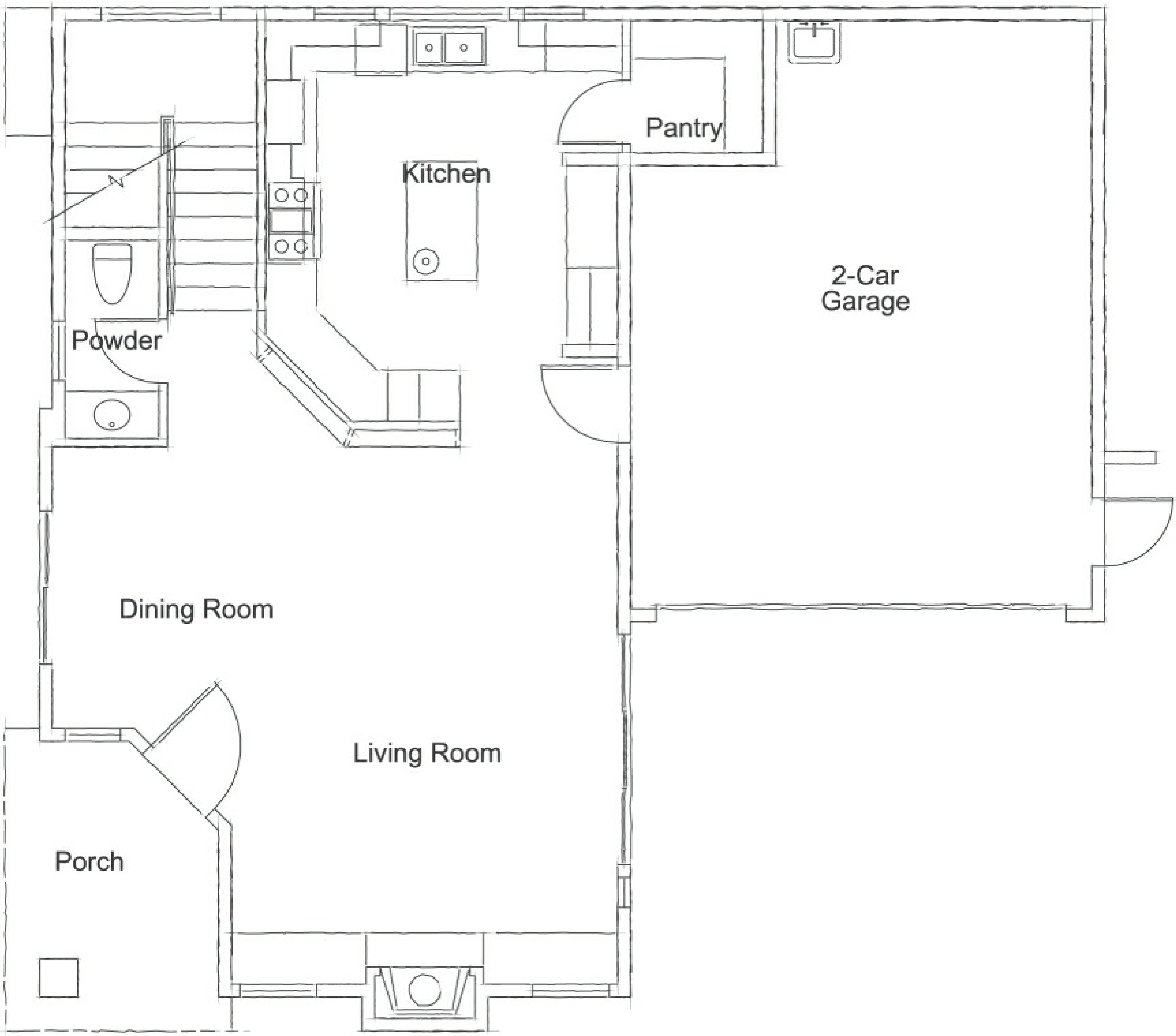


Figure 1.4 First‐floor plan schematic design.

(Courtesy of Nicole Shweiri.)

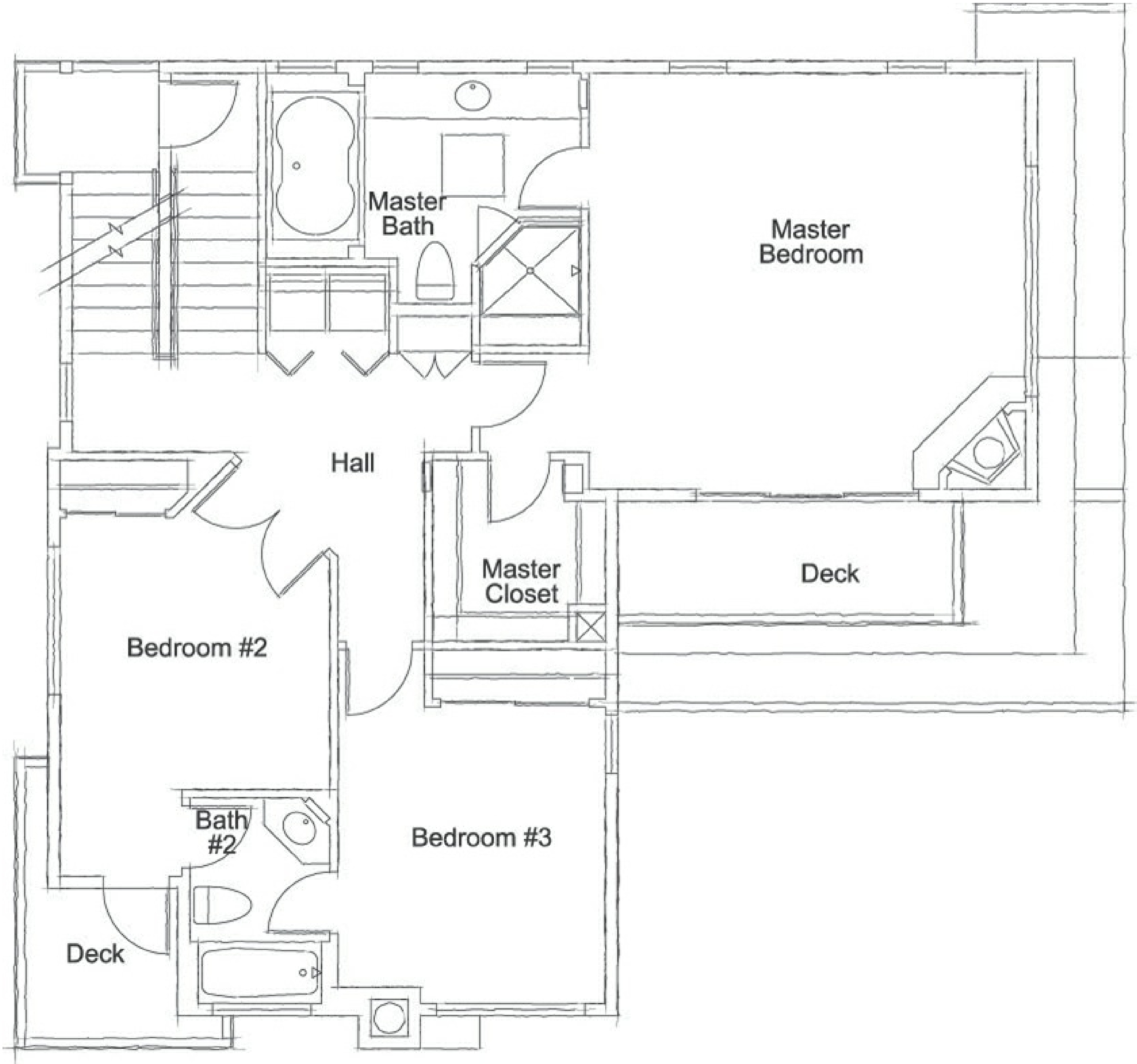


Figure 1.5 Second‐floor plan schematic design.

(Courtesy of Nicole Shweiri.)

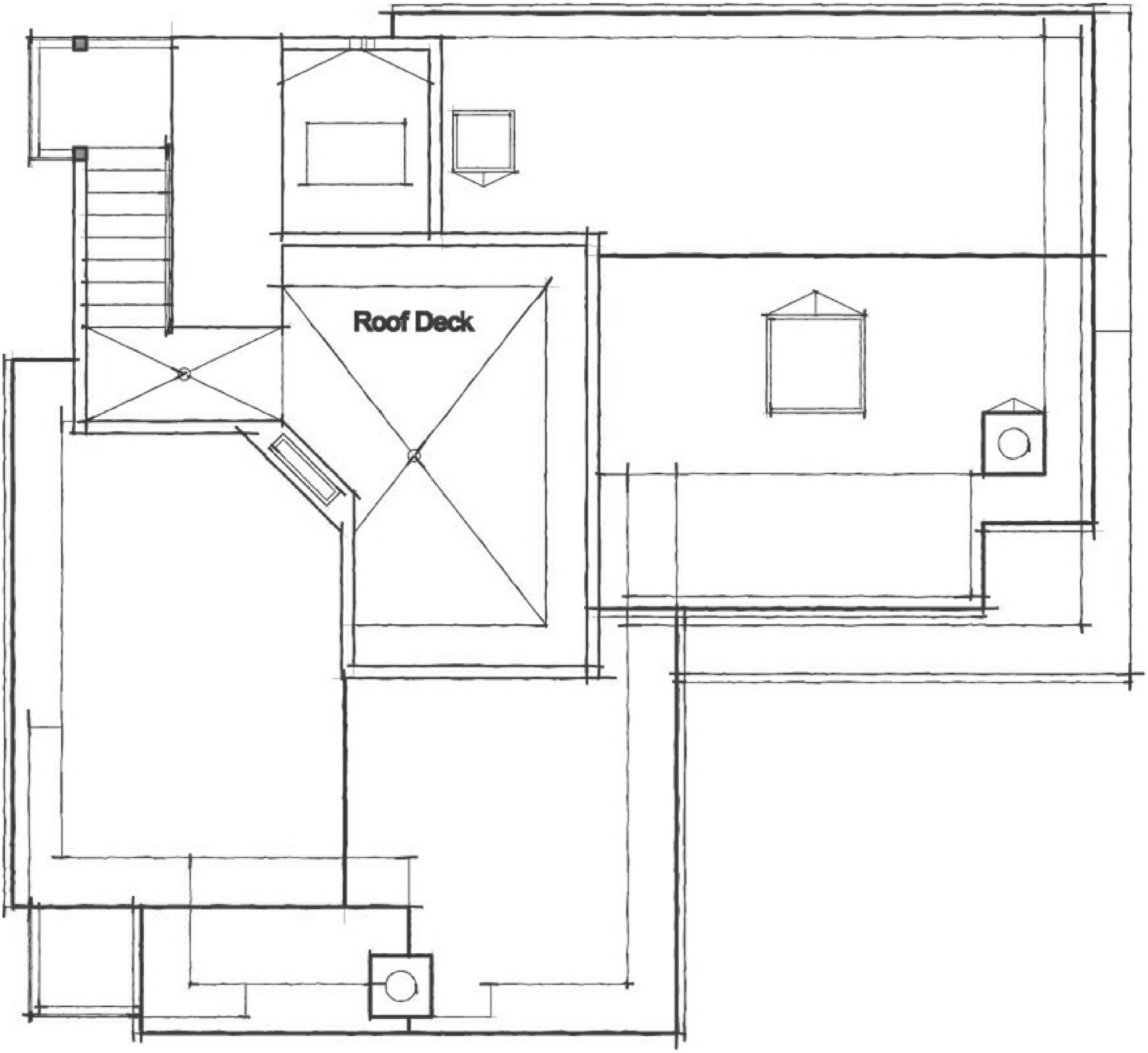


Figure 1.6 Roof plan schematic design.

(Courtesy of Nicole Shweiri.)

Figure 1.7 North elevation schematic design.

(Courtesy of Nicole Shweiri.)

Figure 1.8 West elevation schematic design.

(Courtesy of Nicole Shweiri.)

Design Development

After these numerous reviews of the schematic design, further development and

refinement are required. This improved…drawing design phase is termed **design development (DD)** and represents a more definite solution to the program and the intended building outcome. This phase takes the deliverables from the SD phase and develops them one step further. A primary area of refinement is materiality for the proposed project. During SD, a project may include all the rooms and a resolved floor…plan layout required for the client, but during DD the specific materials to be used in construction of the project will be determined. Small refinements would also be included in DD, such as where the windows and doors as well as fixtures in a kitchen would be located; this is in contrast to schematic design, in which you would just know where the kitchen is located relative to the adjacent rooms. As is the case for schematic design, after several reviews the architect will have the client sign off on the revised plans and budget for the project and move on to the next phase of work.

With a BIM program it is often difficult to determine when DD ends and the next phase begins, because BIM includes so much specific data (such as material type and construction methods) that is front…loaded into the computer. In BIM, even at SD a 3…D drawing of the design has already been developed and can be viewed after a limited amount of data is entered.

Materials and Specifications

There will be many conferences between the architect and the client during the design development phase to select and determine items such as exterior and interior wall finishes, ceiling finishes, flooring, plumbing fixtures, hardware design, type of masonry, roofing materials, and so on. During these conferences, the selections of building equipment and systems are also determined and reviewed. The equipment selection may include such items as types of windows and doors and the manufacturer, elevator type and manufacturer, mechanical system, electrical fixtures, and so on. A deliverable can include notes on the drawings or an actual packet of specifications assembled as a supplement to the drawings.

Construction Documents

After the client and the various governing agencies involved approve the schematic designs and design development for a project, the architect's office initiates the construction drawing phase for the construction of the project. This phase includes drawings with great detail and would typically include specifications and construction details.

During the **construction document (CD)** phase, architects determine which consulting engineers are required on a specific project. The engineers may be employed directly by the architect, or they may have their own private practices. These consultants may include soils and geological engineers, structural engineers, mechanical engineers, electrical engineers, and civil engineers. Other consultants may include landscape architects, interior designers, LEED consultants, and cost estimators. Periodic

conferences with the client are recommended during this phase to attain approvals on the various phases of the construction drawings. These phases or stages may include lighting layout and electrical designs, cabinetry, reflected ceiling, and many other features for which client review and approval are needed.

Upon completion of the construction drawings and specifications, which are now termed *construction documents,* the architect and/or client may submit the CDs to financing institutions for building loans, to various construction firms for building cost proposals, and to governing agencies for their final approvals. Finally, the architectural firm will submit the CDs to the local planning and building department to obtain the required building permits.

Bidding and Negotiating

Once the CDs have been developed, plans are put out to bid. Often accompanying the plans are the instructions to bidders, the bid form, bid documents, the owner…contractor contract agreement, bond requirements, and any added data that is required for completion of the bid process. For public projects, such as schools or state and federal buildings, an unlimited number of bidders can propose a price for completing the work. A public project is typically advertised and provides the minimum qualifications required for the contractor to meet in order to be eligible to bid the construction project. On private projects, the clients may choose who may bid and how many bidders they would like for the job. Often, as many as four or five contractors will bid a job, allowing for a high, mid, and low bid and the opportunity to eliminate an unqualified bid or a bidder that has not met the bid submission deadline.

Negotiation of bids can occur for a project on which a specific price or timeline must be met. A single contractor may be asked to propose a budget and make revisions to replace expensive items or omit items from a project. The result of bid negotiations, ideally, is a modified contract document that will meet the budget and/or time requirements.

In this stage, it is the architect's responsibility to help the owner evaluate the bids and select a winning contractor. Any of the negotiation of scope and bid should be completed prior to the contract execution to minimize the confusion of scope. A letter of intent and a signed contract will be the trigger to allow construction to begin.

Construction Administration

When the construction firm has been selected and construction has commenced, the architect and consulting engineers, according to their agreement in the contract, observe the various phases of construction. This phase in the architecture contract is termed **construction administration (CA)**. At this point, the architect's role may change to one that is more field active. These periodic observations generally correspond to the construction phases, such as field…visiting construction of the foundation, framing, and so forth. The services are determined and outlined in the owner…architect agreement or contract and can be a variety of levels of services. Following their observations, the

architect and consulting engineers provide written reports to the client and contractor describing their observations, along with any recommendations or alterations they deem necessary for the success of the project. Performing site visits, making field revisions and clarifications, and responding to **requests for information (RFIs)** enhance opportunities for better design, budget, and schedule results. The primary role of the architect in this stage is to assist the contractor to build the project as specified in the CDs.

At the completion of the project, the architect and consultants make a final inspection of the construction of the building and prepare a **punch list**. This punch list, which is in written form, includes graphics indicating to the client and construction firm any revisions, reports, or alterations the architect or consultant deems pertinent and reasonable for a successful building project. After the construction firm makes the revisions, the architect and the consultants again inspect the project. If acceptable, a final notice of approval is sent to the client and the construction firm.

BUILDING

Building Codes

The purpose of building codes is to safeguard life, health, and the public welfare. Building codes are continually being revised to incorporate additional regulations based on tests or conditions caused by catastrophic events, such as hurricanes, earthquakes, and fires. In most cases, the governing building codes are similar in organization and context.

The requirements of various agencies and codes are of paramount influence in the design and detailing of today's structures. A great number of codes govern and regulate the many elements that are integrated into the construction of a building. The major codes that are used in the design and detailing of buildings are the building code, mechanical code, electrical code, fire code, energy code, and accessibility design criteria for compliance with the **Americans with Disabilities Act (ADA)**.

Procedures for Use of Building Codes

Step I. *Building use and occupancy*. The first step is to classify the building use and to determine the occupancy group for the building. When the occupancy classification has been determined, the building is assigned a group designation letter, which determines the description of the occupancy and the group it falls under.

Step II. *Fire…rated wall assemblies*. Most codes provide a chapter on acceptable fire…resistive standards for assemblies, so that the architect is able to select an assembly that satisfies his or her specific condition. For example, a one…hour fire…rated wall is constructed with 2″ × 4″ wood stud partition with 5/8″ type “X” gypsum wallboard on both sides.

Step III. *Building location on the site*. The location of the building on the site and

the clearances to the property lines and other structures on the site determine the fire…resistant construction of the exterior walls. The openings are based on the distances from the property lines and other structures.

Step IV. *Allowable floor areas*. The next step is to determine the proposed and allowable floor areas of the building based on the occupancy group, such as theater or assembly room, and the type of construction.

Step V. *Height and the number of stories or floors in the building*. The architect computes the maximum height of the building and determines the number of stories and/or floors. The maximum number of stories and the height of the building are determined by the building occupancy and the type of construction.

Code Influence on Building Design

An example of code…related design requirements is provided by a site plan for a proposed two…story office building. The architect desires that all four sides of the building have windows. To satisfy this design factor, the minimum building setback from the property line will be a minimum 10 feet for openings in exterior walls. Figure 1.9 depicts the proposed site plan for the two…story office building, showing property line setbacks satisfying one design requirement.

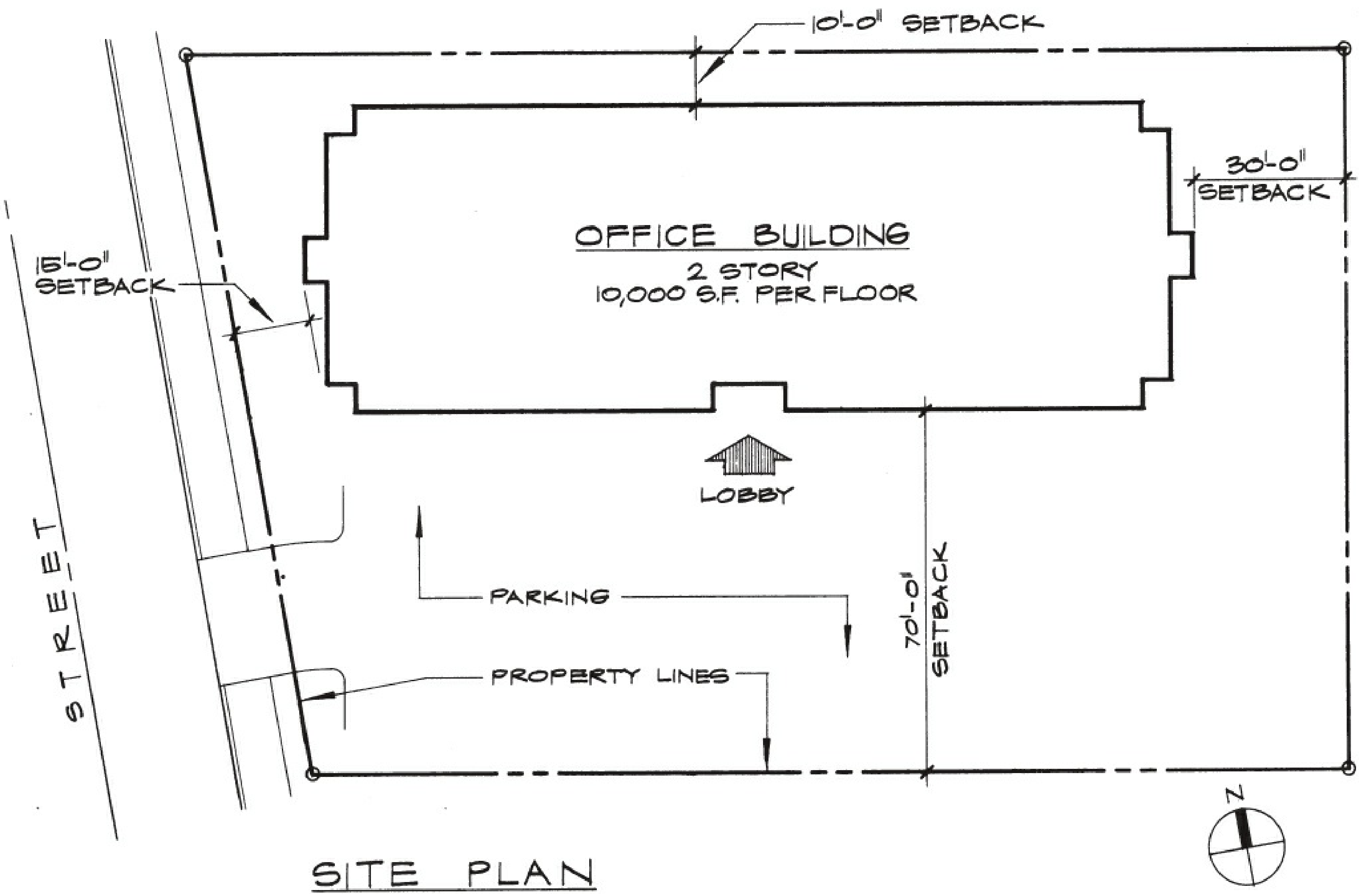


Figure 1.9 Site plan with setbacks illustrated.

As the design program is developed, it is helpful to provide code‥required assemblies in graphic form as a visual means for reviewing what is required for the various elements of the office building. An example of such a graphic aid appears in Figure 1.10. Building codes specify the wall assemblies that meet the fire‥resistive requirements for the various elements of the building type selected.

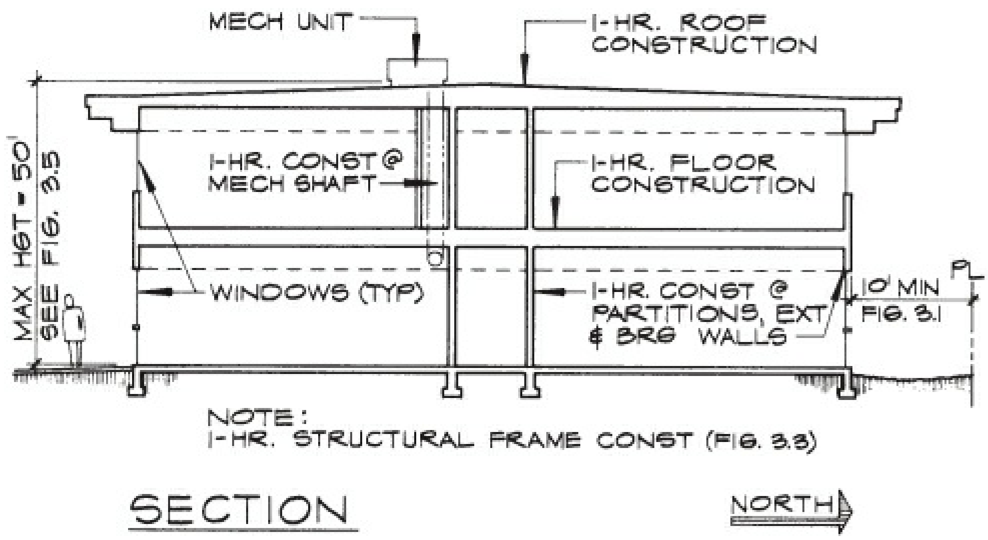
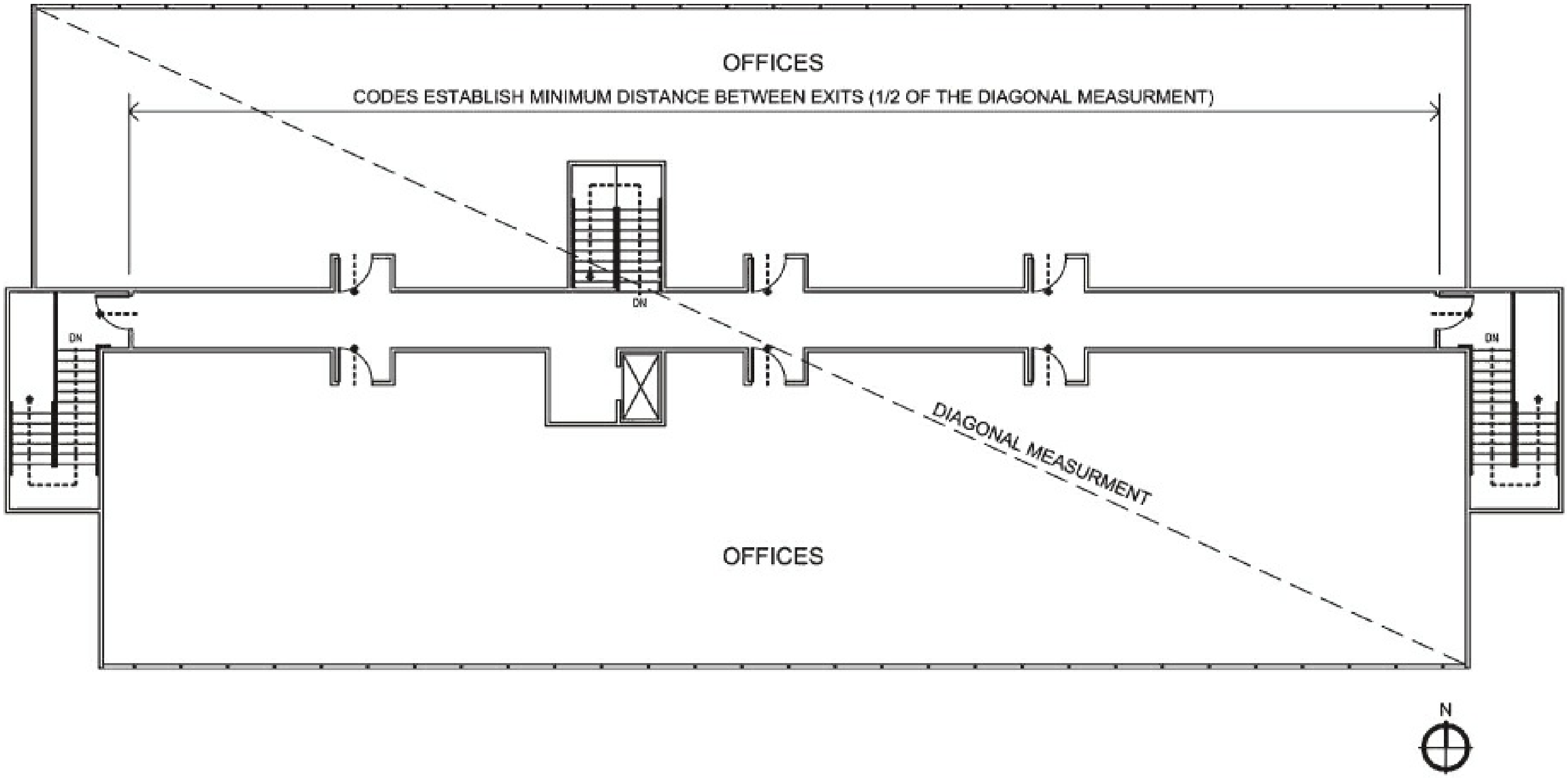


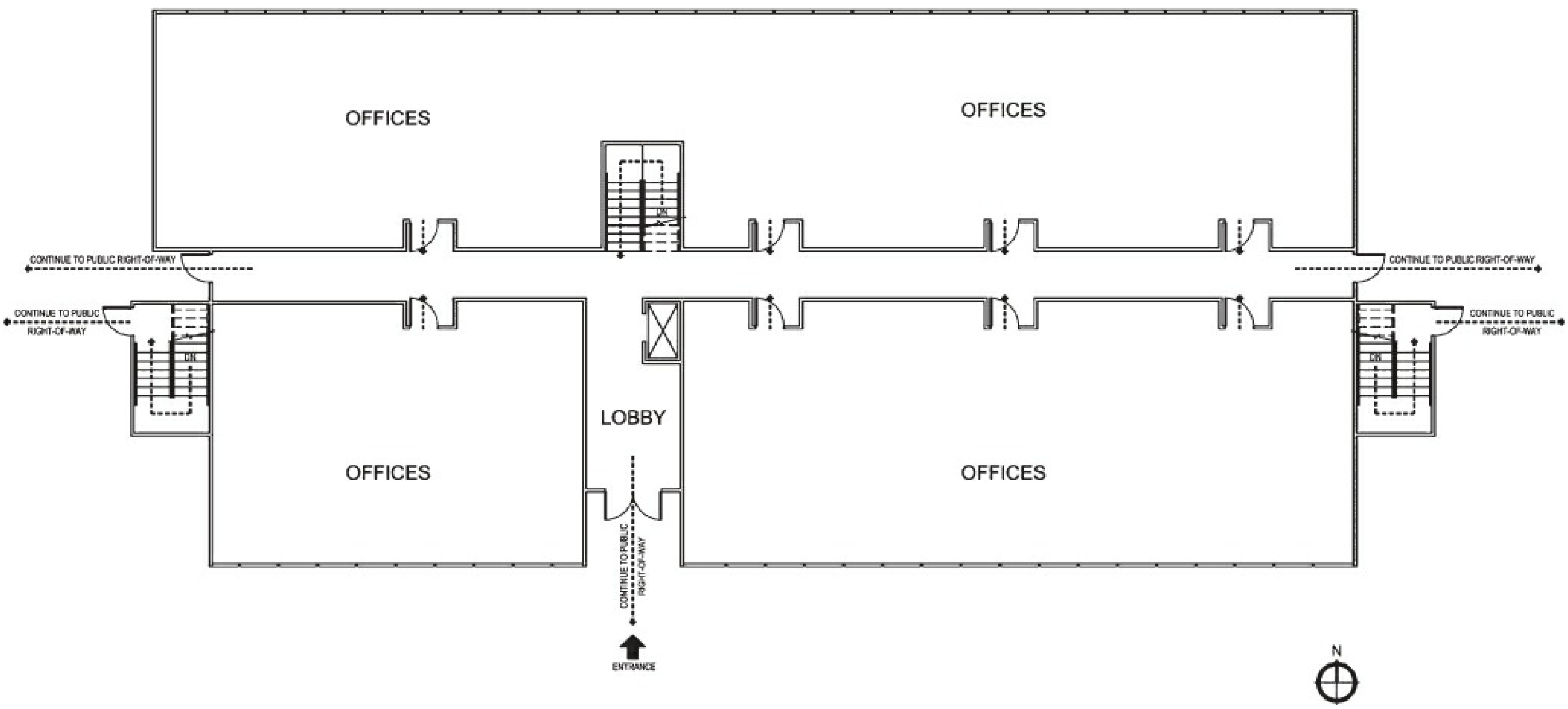
Figure 1.10 Graphic building section with fire‥rated assembly.

Exit Requirements. Another very important part of a building code is the chapter dealing with egress requirements. This chapter sets forth the number of required exits for a specific occupancy use, based on an occupant load factor. The occupant load will depend on the use of the building. In the case of a two‥story building that is designed for office use, the occupant load factor is 1 person per 100 square feet. To determine the number of exits required, the 100‥square‥foot occupant load factor is divided into the office floor area of 10,000 square feet. The resulting occupant factor of 100 exceeds the factor of 30, therefore requiring a minimum of two exits.

The next step in the design program is to plan the location of the required exits, required stairs, and an acceptable *egress travel* (the path to a required exit). Building codes regulate the maximum distance between exits, the minimum width of exit corridors, and the entire design of required exit stairways. Figure 1.11 depicts the second‥level floor plan of the proposed office building, illustrating an acceptable method for the planning of required exits and stair locations. An acceptable egress travel will terminate at the first‥floor level, exiting outside the structure to a public right‥of‥way. A public right‥of‥way may be a sidewalk, street, alley, or other passage. On the first‥level floor plan, illustrated in Figure 1.12, the egress travel path terminates outside the building through an exit corridor at the east and west walls of the building.



[Figure 1.11](#) Second‐level floor plan.



[Figure 1.12](#) First‐level floor plan.

BUILDING INFORMATION MODELING ON BUILDING DESIGN

For centuries, architects have embraced new methods, new materials, and new technologies. This embrace accelerates the evolution of the field of architecture and shapes our built environment. BIM is such a technology, and it is setting new precedents

in the world of architecture as we know it. Offering the drafter increased accuracy, productivity, collaboration, and organization—all while reducing repetition—BIM is a process of drafting in which almost every detail of a building assembly is included from its fundamental parts. For example, details such as stud, sheathing, building paper, lath, plaster, and gypsum are included to define a specific wall type. Where earlier programs established two lines to represent a wall, BIM identifies the entire wall with specificity.

Programs such as Revit by Autodesk, ArchiCAD, and Bentley are designed to increase productivity in all phases of drawing documentation. Its primary advantage is its ability to produce drawings that are generated by defining floor, wall, and roof assembly types. In addition, BIM will develop schedules, identify doors and windows from the placement, and determine door and window sizes and types. Finish schedules are also established by using information on floor, wall, and roof materials. BIM will even go further in developing detailed sections, elevations, and details.

It is amazing how such a program can aid in development of a construction set of drawings. This advantage is further enhanced by its process capability to modify all the plans, schedules, and elevations to reflect the changes when modifications are made. A standard drafting program would require a technician to modify all the plans based on his or her own experience. Of course, the program is not perfect, but it does include a conflict detection element to aid in the process. Simply put, one can develop a more accurate, thorough, and coordinated set of drawings with the aid of Revit, Bentley, or other BIM technologies.

Key Terms

American Institute of Architects (AIA)

Americans with Disabilities Act (ADA)

apprenticeship

Architecture Registration Examination (ARE)

building information modeling (BIM)

computer…aided drafting (CAD)

construction administration (CA)

construction document (CD)

corporations

design development (DD)

human resources (HR)

Intern Development Program (IDP)

internship

Leadership in Energy and Environmental Design (LEED)

MasterFormat

National Architectural Accrediting Board (NAAB)

National Council of Architectural Registration Boards (NCARB)

partnership

programming

project architect

punch list

redlines

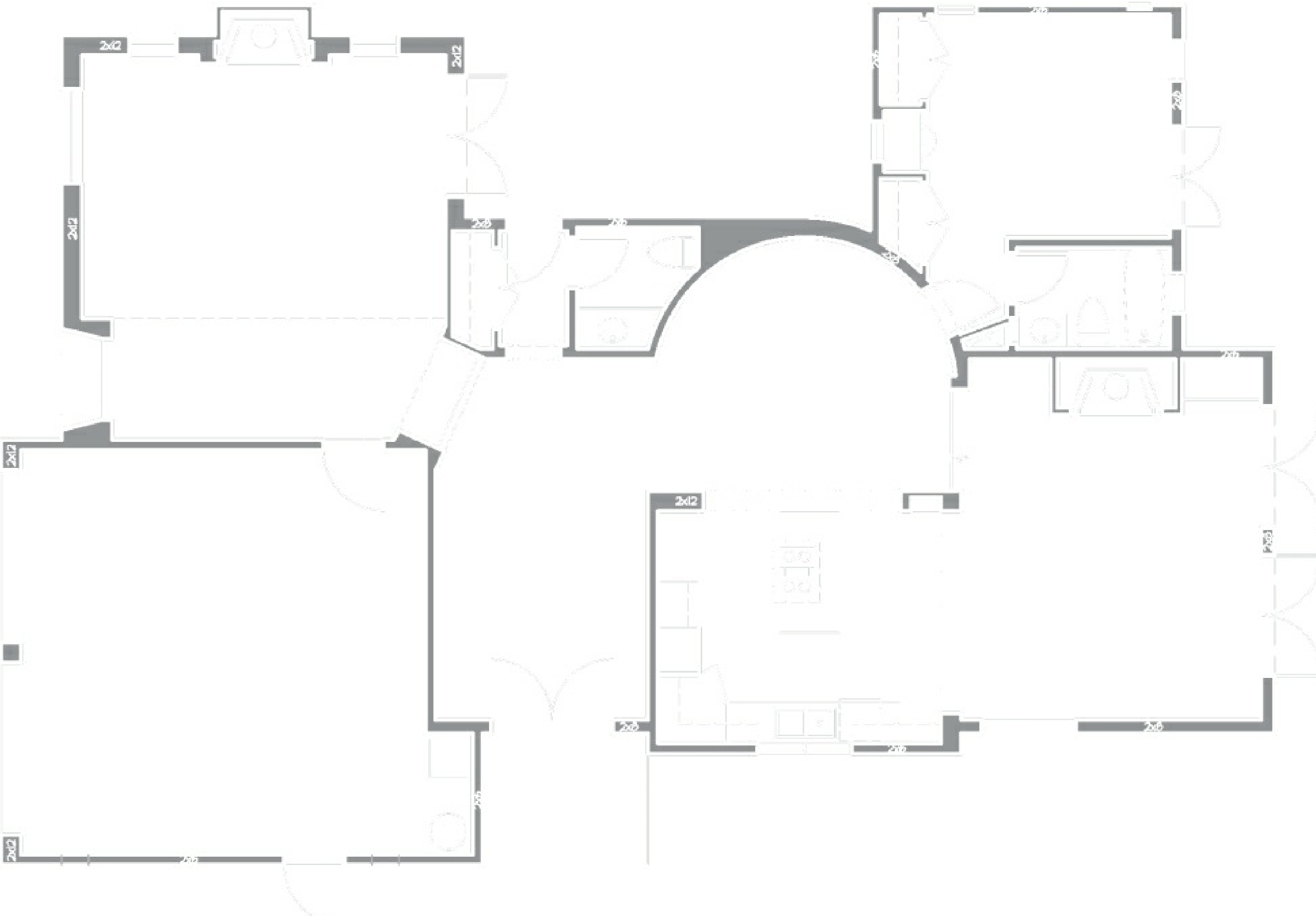
requests for information (RFIs)

schematic design (SD)

sole proprietorship

space planning

Chapter 2
STANDARDS AND TECHNIQUES, HAND DRAFTING, COMPUTER-AIDED DRAFTING, AND METRIFICATION



STANDARDS AND TECHNIQUES INTRODUCTION

Standards and techniques are used to create a uniform system both nationally and internationally. Standardizing these will not eliminate creativity, as creativity is inherent in the design of the building, but the integrity of the design must be totally understood by those responsible for producing working drawings. If one of the employees is transferred to another department in the same office, their replacement must understand the design form enabling them to make an accurate translation of the construction documents. This action maintains a uniform approach throughout our profession, while maintaining control over the drawings, and ensures craftsmanship and workmanship in architecture.

The main reason for this portion of the text is to explain how critical it is to follow the prescribed standards that should be used by all architectural offices. These standards are based on the American Institute of Architects (AIA) standards prescribed here and

throughout the text. While architecture is a creative art, you should not attempt to create your own standards because it will only confuse your associates, contractors, and the subcontractors. So at the beginning of your architectural education, you must subscribe to these standards, which later will give you the edge as freshmen and sophomores begin to establish their foundation toward seeking employment.

This chapter covers four points:

1. Understanding the vocabulary of our profession
2. Metrification
3. Hand drafting
4. Computer…assisted drafting (CAD)

Chapters 3 and 4 discuss the third phase of the evolution of drafting, building information modeling (BIM), and one of many new programs that have evolved programs that translates BIM. A technical program was selected for this text and introduces a new vocabulary, which will be discussed in detail in Chapter 15.

Learning architecture is similar to learning a new language. First, you must build vocabulary, assemble the words in a prescribed order, and punctuate to show the real intent of the phrase. The language of architecture is made up of lines with certain densities and conventions used nationally to denote a particular item, such as a door and its swing, an electrical symbol, and structural components. Standards have evolved to ensure and enhance comprehensibility of drawings; notations that follow the prescribed form are easily and quickly understood, thereby saving time and reducing the possibility of error. Architecture in the distant past was a local thing, but in the recent past our endeavors have expanded to a national and even global level.

The process of architectural technology is continually changing, from hand drafting to CAD to the newest BIM, and even in the technical aspects of architecture such as the use of new materials and methods of construction, which have an impact on the way information is organized.

Drawing Practice

The actual practice of drawing must follow standards. Standards are prescribed to the drafter for both manual and computer drafting, and have become the foundation for the translation of drawings from design drawings to construction documents.

With the possible exception of lettering, the following descriptions of line quality, material designation, profiling, dimensioning, and so forth, are for enhancement of the images (drawings) that we are preparing, and as such are not applicable to manual drafting.

Lines and Line Quality

Lines can be broken down into three types: light, medium, and dark. Each of these types can be broken down further by variation of pressure and lead.

Light Lines. The lightest lines used are usually the guidelines drawn to help with lettering height. These lines should be only barely visible and should completely disappear when a print is made. See Figure 2.1A. At the darker end of the light line spectrum are lines for door swings or other less significant objects.

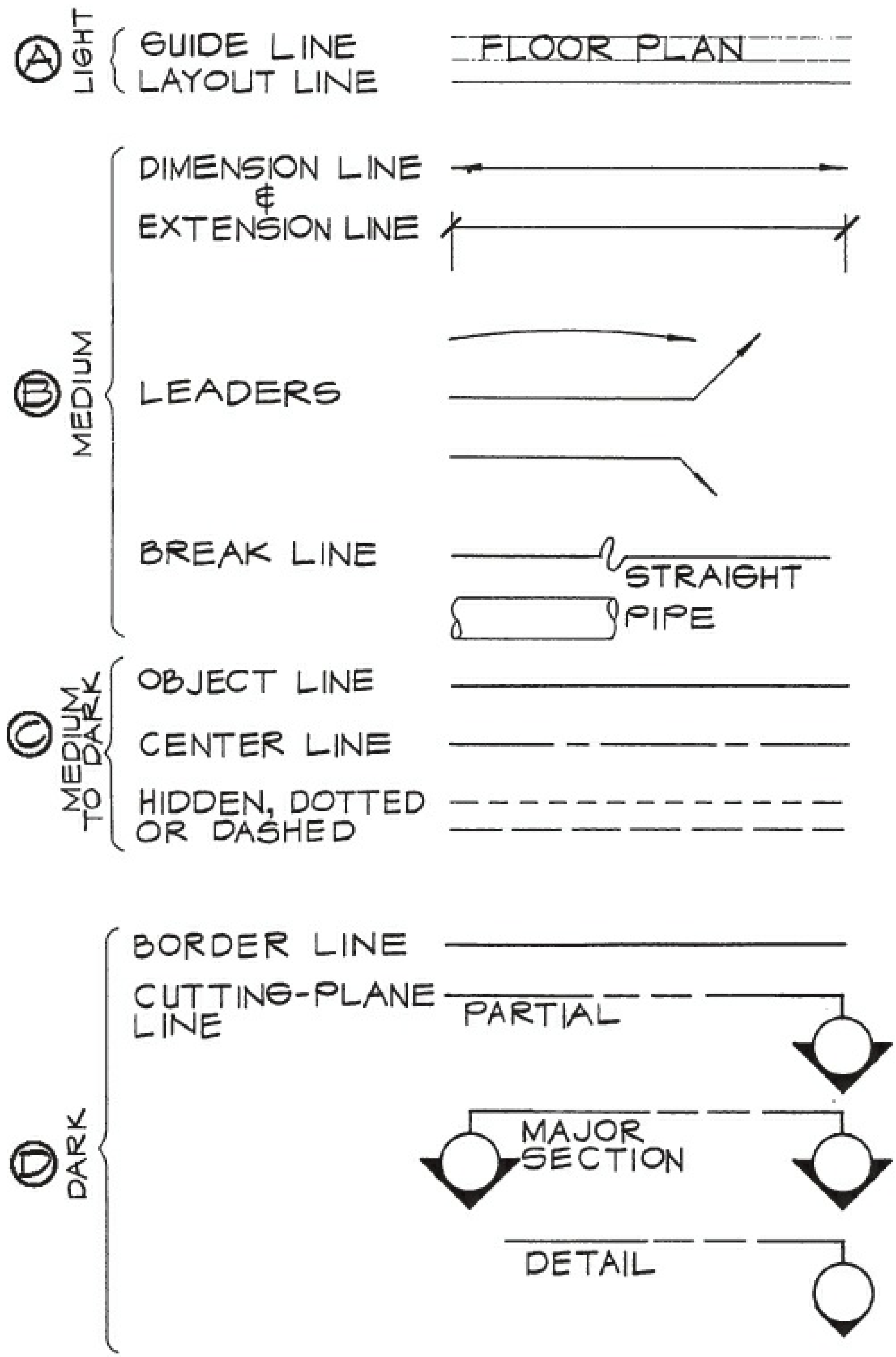


Figure 2.1 Vocabulary of architectural lines.

Medium Lines. Medium…weight lines are used for dimension lines and extension leaders. Leaders and break lines also use medium…weight lines. See Figure 2.1B. They can

also be used for such nonstructural components as bath fixtures or cabinets.

Medium_Dark Lines. Medium to dark (darkest of this group) lines are used to describe objects (object lines) and for centerlines. Medium to slight dark lines are used for hidden or dashed lines. See Figure 2.1C.

Dark Lines. The darkest lines are used to profile objects, for border lines if they are not predrawn on the vellum, and for cutting plane lines. See Figure 2.1D. Walls or structural components of a building would be at the lighter end of the spectrum of dark lines.

Choosing Line Quality. Line quality depends on the use of that particular line. An intense line is used to profile and emphasize, an intermediate line is used to show elements such as walls and structural members, and a light line is used for elements such as dimensioning and door swings.

Another way to vary line quality is to increase the width of the line. A thicker line can represent the walls on a floor plan, the outline of a building on a site plan, or the outline of a roof on a roof plan. For line‥quality examples and uses, see Figure 2.2, which shows a sample of the types of lines used to indicate property lines and easements.

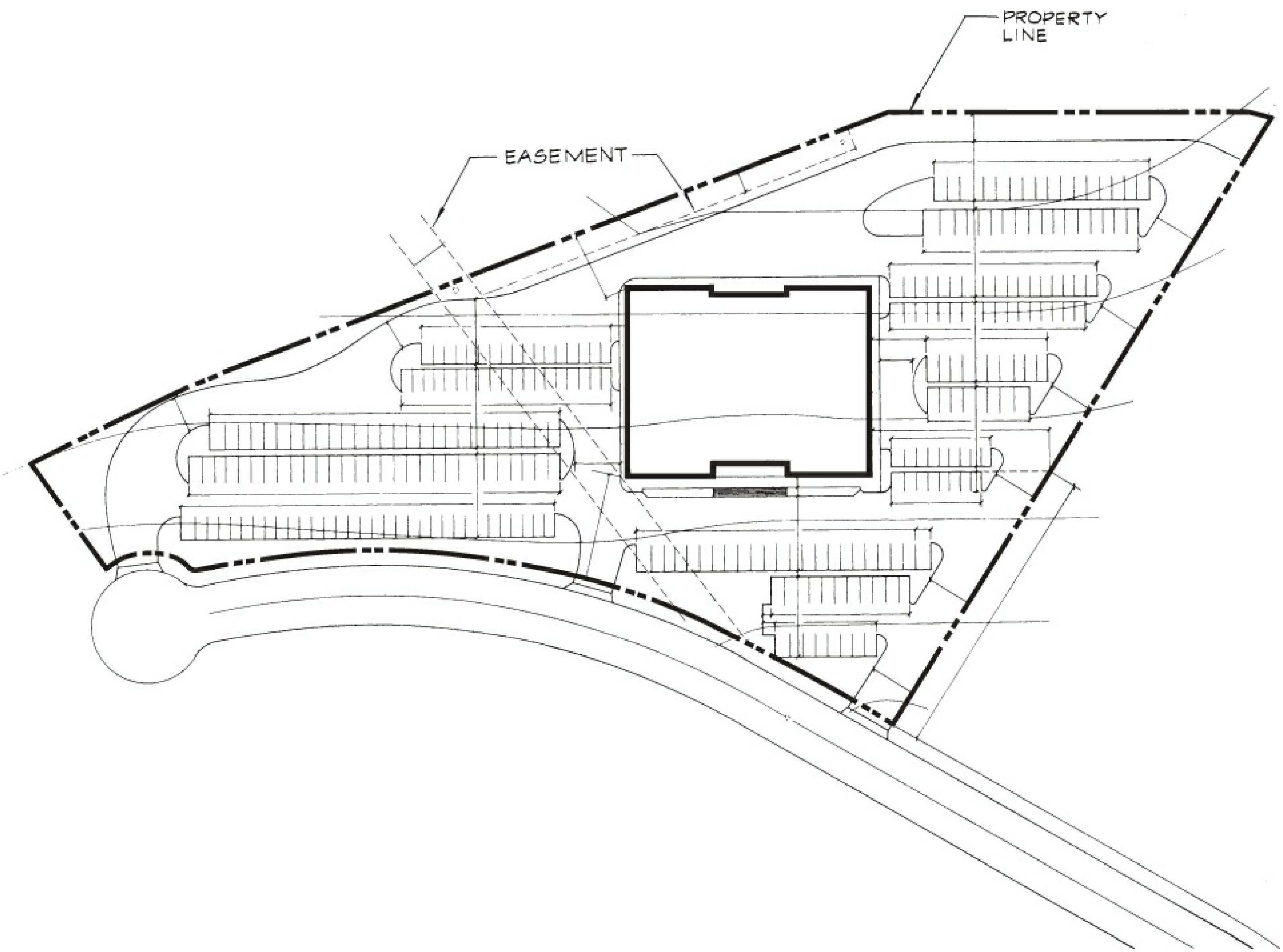


Figure 2.2 Types of lines used for property lines and easements.

Hidden or Dotted Lines. Hidden or dotted lines are used to indicate objects hidden from view. Solid objects covered by earth, such as foundations, can be indicated with hidden lines. This type of line can also depict future structures, items that are not in the contract, public utilities locations, easements, a wheelchair turning radius, or the direction of sliding doors and windows. Such lines are often used to delineate walls that are to be removed or demolished.

A floor plan will often show the roof outline, a balcony above, or a change in ceiling height with a dotted line. On a site plan, dotted lines indicate the existing grades on the site (see Chapter 4).

Arrowheads. Different types of arrowheads are used in dimensioning. These are shown in Figure 2.3. The top one is used architecturally more for leaders than for dimension lines. The second one, with the tick mark, is the arrowhead most prevalently used in our field. The dot is used in conjunction with the tick mark when you are dimensioning two systems. For example, the dot can be used to locate the center of steel columns, and the tick mark can be used to dimension the secondary structure within a building built of wood. The final wide arrowhead is used as a design arrowhead in many offices.

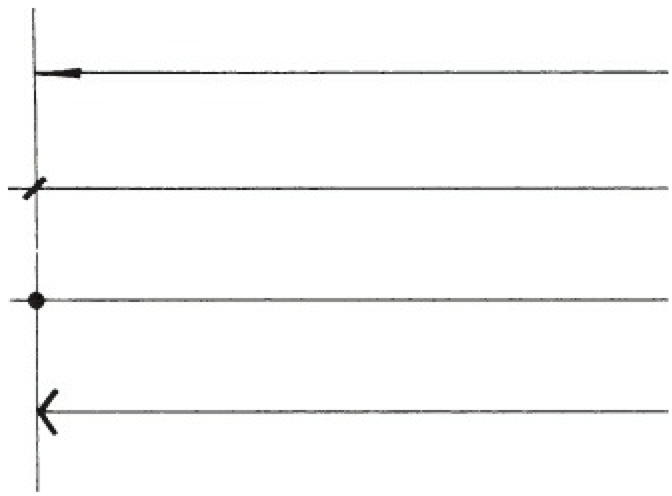


Figure 2.3 Types of arrowheads used in dimensioning.

Material Designation Lines. Material designation lines are used to indicate the building material used. See Figure 2.4 for a sample of tapered or light…dark lines. (This device saves time; complete lines take longer to draw.) Also note the cross…hatched lines between the parallel lines that represent the wall thickness on Figure 2.5. These diagonal lines represent masonry.

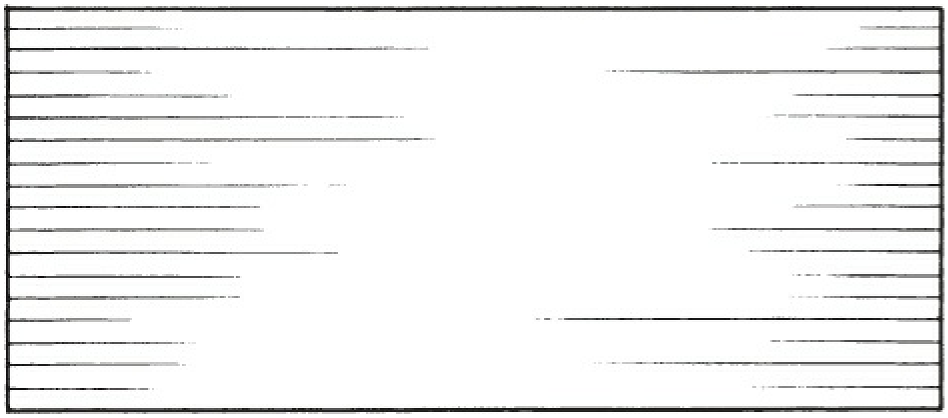


Figure 2.4 Tapered lines.

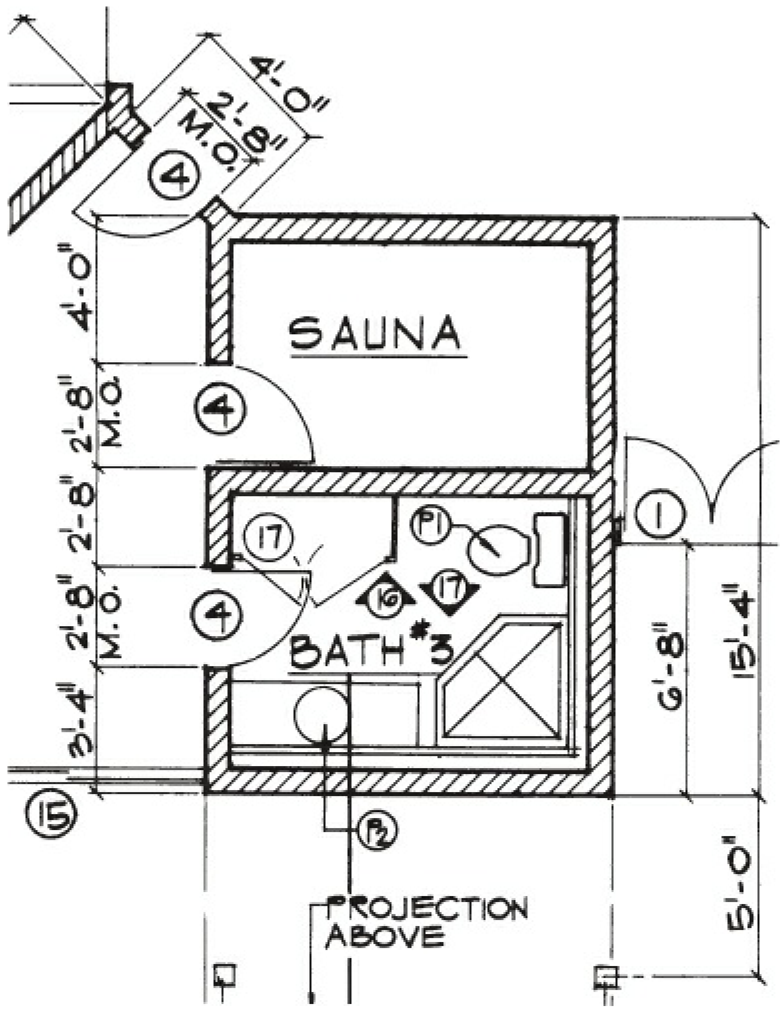


Figure 2.5 Lines representing masonry.

Profiling. Architectural profiling is the process of taking the most important features of a drawing and outlining them. Figure 2.6 shows four applications of this concept.

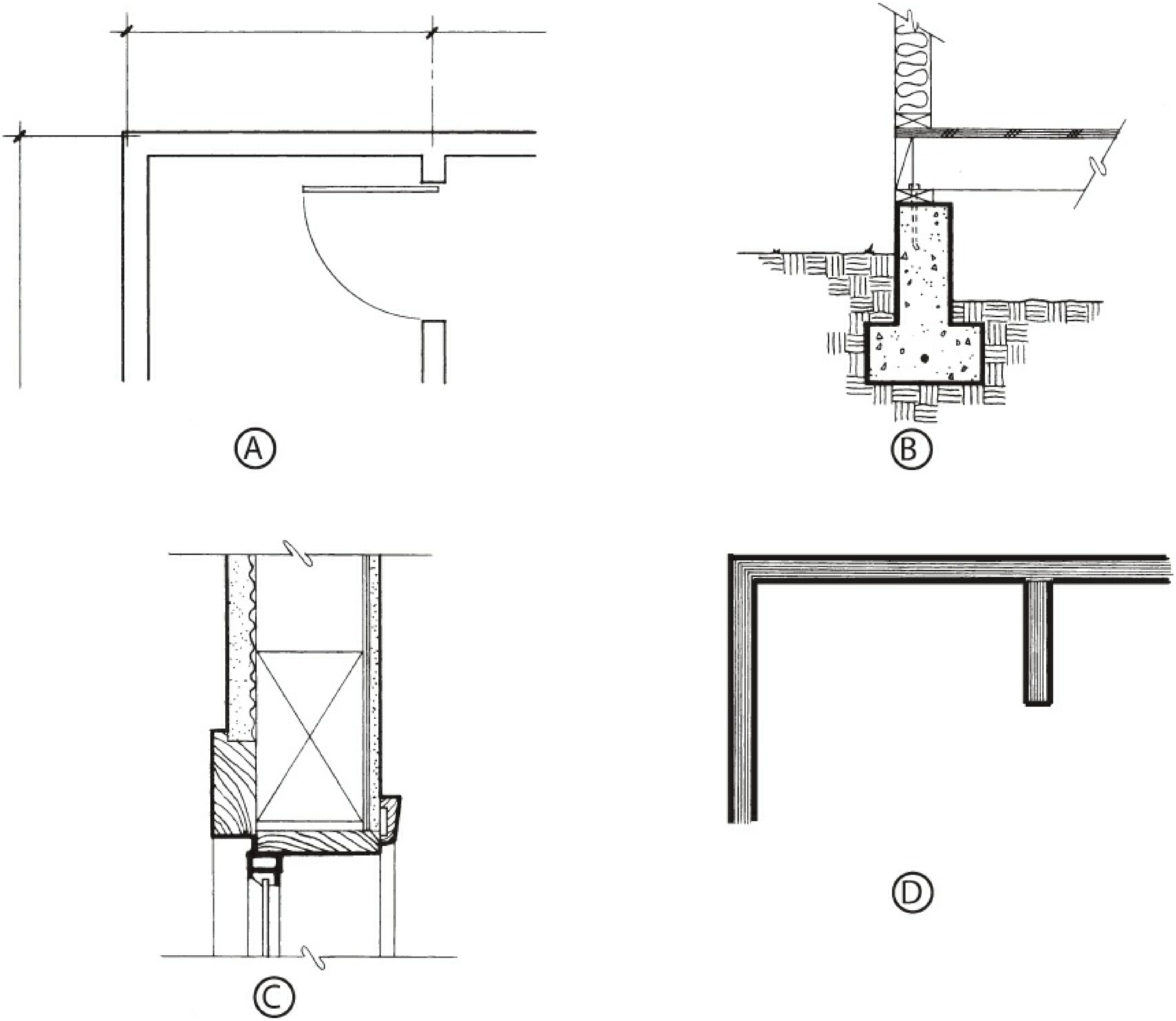


Figure 2.6 Profiling.

Example A illustrates the darkening of the lines that represent the walls of a floor plan. The dimension lines or extension lines are drawn as medium…weight lines not only to contrast with the walls but also to allow the walls of the particular floor plan to stand out.

In example B, a footing detail is profiled. Because the concrete work is important here, its outline is drawn darker than any other part of the detail.

Example C shows the top portion **(head)** of a window. The light lines at the bottom of the detail represent the side **(jamb)** of the window. Note how the head section is outlined and the interior parts plus the sides of the walls are drawn lightly.

Example D represents another form of profiling, called **poché,** which enhances the profile technique by using shading. The technique of using shading is limited to design drawings; in construction documents, poché on a wall indicates a bearing wall, or a new

wall in an addition or alteration. This shading can be done by pencil shading or by lines. Example B also uses this principle: In this instance, the dots and triangles that represent concrete in section are placed along the perimeter (near the profiled line) in greater quantity than toward the center.

In a section drawing, the items most often profiled are cut by the cutting plane line. A footing detail, for example, is nothing more than a theoretical knife (a cutting plane) cutting through the wall of the structure. The portion most often cut is the concrete, so it is profiled.

On an elevation, the main outline of the structure should be darkened. See Figure 2.7. This type of profiling is used to simplify the illusion of the elevation to show that the structure is basically an L…shaped structure and that one portion does actually project forward.

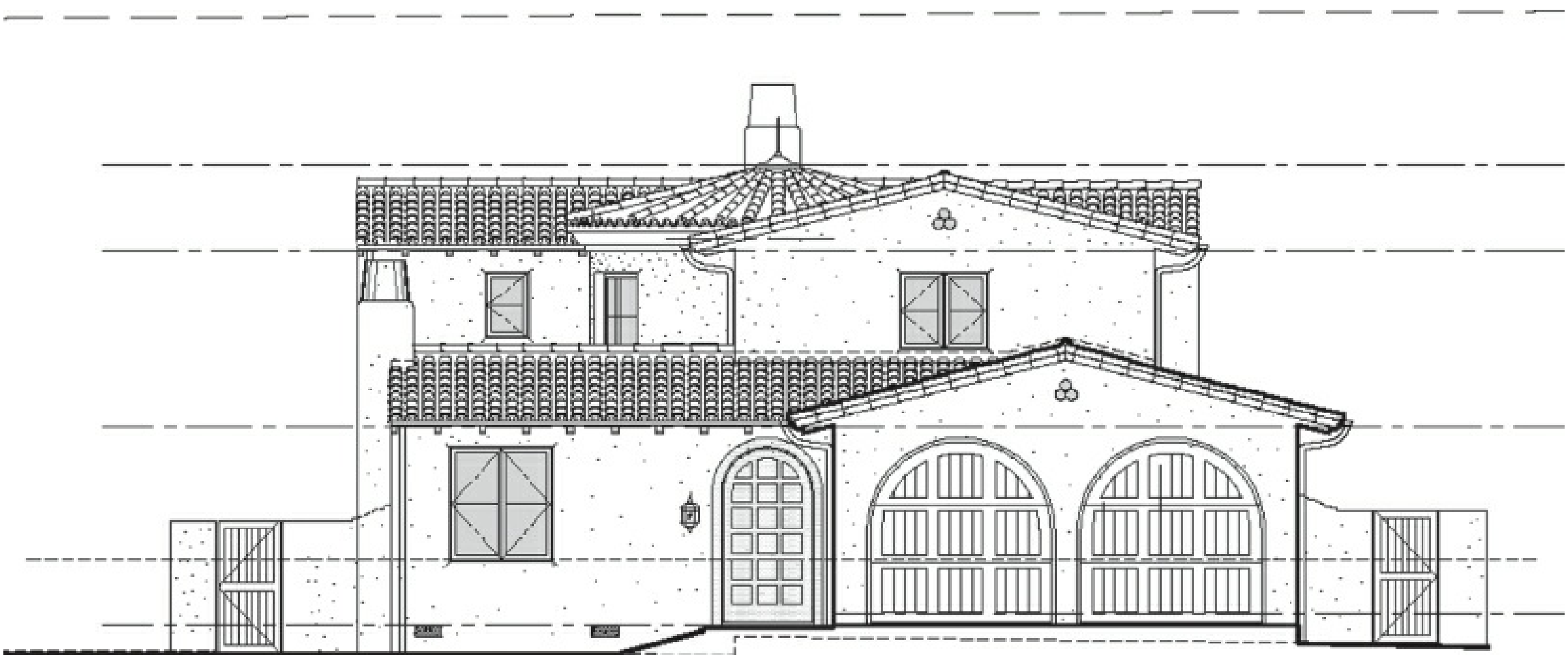
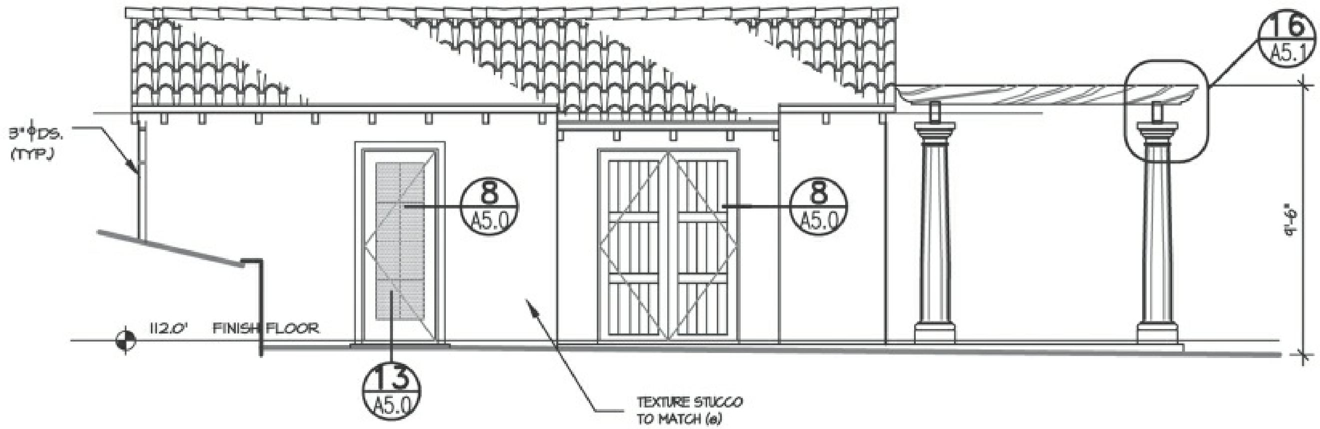


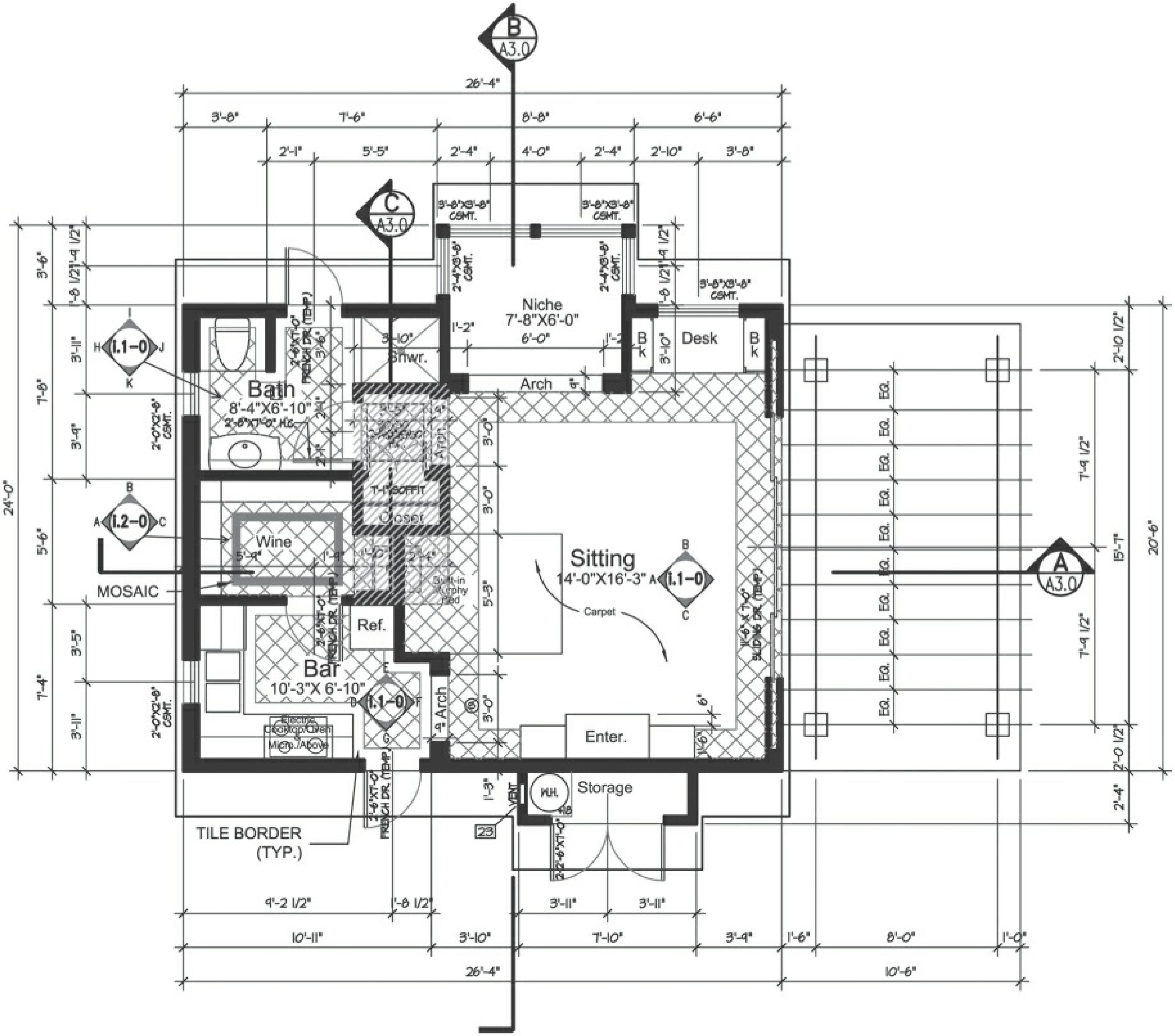
Figure 2.7 Correctly profiled elevation.

In the plan view, often the outline of the main structure is heavily outlined (profiled) in order to make the main area stand out more than any other feature of the property. See Figure 2.8 for a finished plan and elevation that have been properly profiled.



SOUTH / EAST ELEVATION

SCALE: 1/4" = 1'-0"



FLOOR PLAN @ POOLHOUSE

SCALE: 1/4" = 1'-0"

Figure 2.8 Correctly profiled plan and elevation.

Lettering

Importance of Hand Lettering. Being able to hand letter well becomes very important not only to maintain eye…hand coordination but to accurately communicate by handwritten notes with an office and particularly when correcting drawings. This is especially true when correcting computer…generated construction documents. Take, for example, a computer…generated roof framing plan. Let us say the CAD drafter mislabeled a rafter on the plan and posted a 2 × 4 rafter at 12″ on center as a note, whereas in reality the rafter should have been a 2 × 6 rafter at 16″ center to center. For some strange reason, errors of this kind are usually discovered only after the document is printed and during the reproduction of multiple field copies. At this point, it takes a time…consuming effort to locate the drawing in the computer's memory, correct it, and replot the drawing, not to mention the cost of supplies. Had the note been printed in an architectural font, it would be a simple matter to erase the error and reletter it by hand on the already printed document. This would be a five…minute task. For this reason, it makes sense not only to use an architectural font on computer…generated drawings for dimensions, notes, and call…outs that may change, but also to master hand lettering and manual drafting as well.

Architectural lettering differs somewhat from the Gothic…type letters developed by C. W. Reinhardt about 80…plus years ago and now called *mechanical lettering*. Architectural lettering has evolved from a series of influences, including the demand for speed. We must not, however, interpret speed to mean or allow sloppiness.

Another influence on architectural lettering was style. The architecturally drafted plan was in essence an idea or concept on paper, a creative endeavor. Thus, the lines and the lettering took on a characteristic style of their own. In many firms, stylized lettering serves to identify the individual draftsperson. However, most firms attempt to create a uniform style of lettering that is used by the entire staff. Stylizing must not be confused with overdecoration. Lettering that looks like a new alphabet cannot be justified in the name of stylization.

Basic Rules for Lettering and Numbering. Following are a few simple rules for lettering and numbering:

1. Master mechanical lettering before attempting architectural lettering or any type of stylization. A drafter who cannot letter well in mechanical drafting has less chance of developing good architectural letters.
2. Learn to letter with vertical strokes first. Sloping letters may be easier to master, but most architectural offices prefer vertical lettering. It is easier to change from vertical to sloping letters than the reverse. See Figure 2.9.

VERTICAL LETTERS SLOPING LETTERS

Figure 2.9 Comparison between vertical and sloping lettering.

3. Practice words, phrases, and numbers—not just individual letters. Copy a phrase from this book, for example.
4. The shape of a letter should not be changed. The proportion of the letter may be slightly altered, but one should never destroy the letter's original image. Although the middle example "W" in Figure 2.10 is in a style used for speed, it can be misconstrued as an "I" and a "V."

Figure 2.10 Overworking architectural letters.

5. Changing the proportions of letters changes their visual effect. See Figure 2.11.

Figure 2.11 Changing letter proportions to produce architectural effect.

6. Certain strokes can be emphasized so that one letter is not mistaken for another. This also forces the draftsperson to be more definitive in the formation of individual strokes. The strokes emphasized should be those most important to that letter; for example, a "B" differs from an "R" by the rounded lower right stroke, and an "L" from an "I" by the horizontal bottom stroke extending to the right only. The beginning or end of these strokes can be emphasized by bearing down on the pencil to ensure a good reprint of that portion. See Figure 2.12.

Figure 2.12 Emphasis on certain strokes.

7. Maintain all uppercase lettering. Do not pick up the bad habit of mixing upper… and lowercase letters.
8. Maintain proper spacing between letters and do not leave space within the letter that is not properly there. See Figure 2.13.

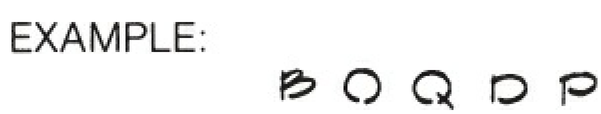


Figure 2.13 Spaces incorrectly left within letters.

9. Consistency produces good lettering. If vertical lines are used, they must all be parallel. A slight variation produces poor lettering. Even round letters such as "O" have a center through which imaginary vertical strokes should go. See Figure 2.14.

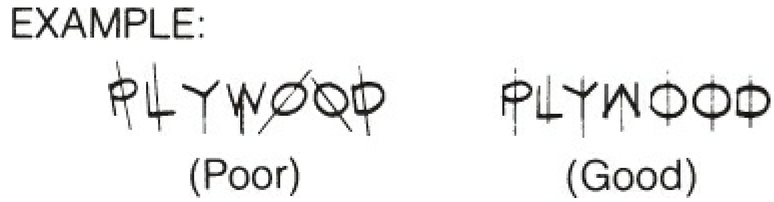


Figure 2.14 Producing consistency.

10. Second only to the letter itself in importance is spacing. Good spacing protects good letter formation. Poor spacing destroys even the best lettering. See Figure 2.15.

Figure 2.15 Importance of good spacing.

11. Always use guidelines. Let your letters touch the top and bottom guideline but not extend beyond it. See Figure 2.16.

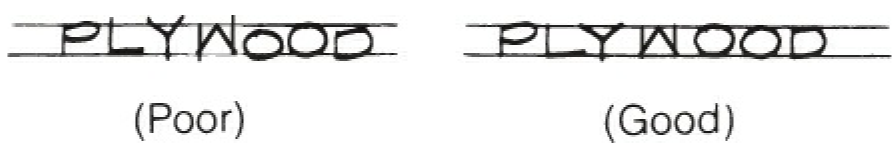


Figure 2.16 Full use of guidelines.

Using Guidelines. Although a purist might frown on the practice, a guideline or straightedge can be used in lettering to speed up the learning process. Horizontal lines are easier for a beginner than vertical lines, and shapes appear better formed when all of the vertical strokes are perfectly perpendicular and parallel to each other. Curved and round strokes are done without the aid of an instrument. Placing lined paper under the vellum is also a good trick to use, as is using grid vellum.

After drawing the guidelines, place a parallel about 2 or 3 inches. Relocate the straightedge below the lines. Place the triangle to the left of the area to be lettered, with the vertical portion of the triangle on the right side. See Figure 2.17. “Eyeball” the spacing of the letter. Position your pencil as if you were ready to make the vertical line without the triangle. Before you make the vertical stroke, slide the triangle over against the pencil and make the stroke. See Figures 2.18 and 2.19. Draw nonvertical lines freehand. See Figure 2.20.

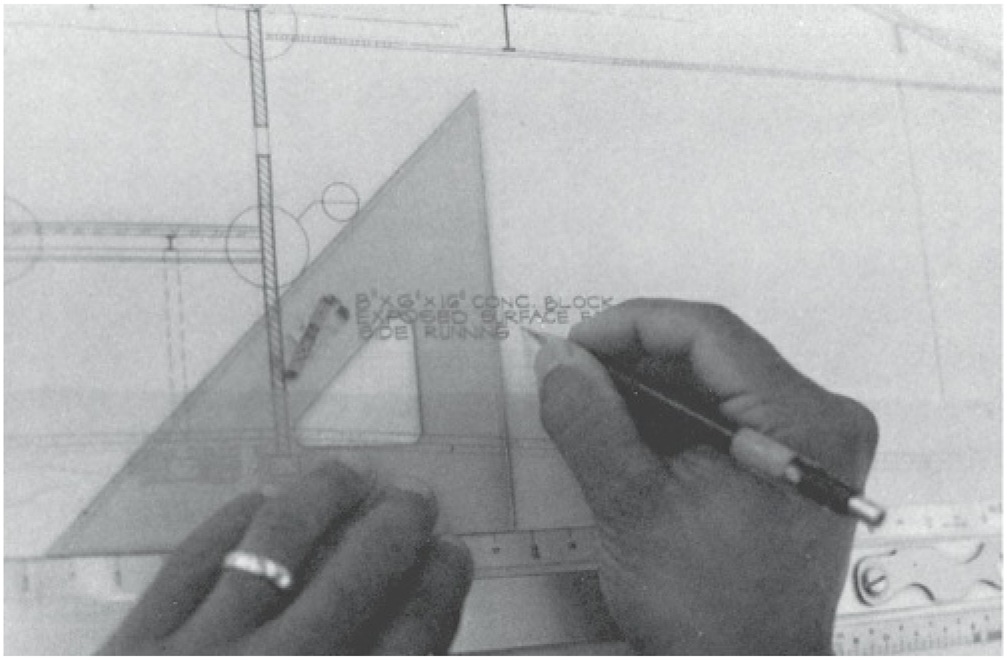


Figure 2.17 Pencil placement for vertical lettering.

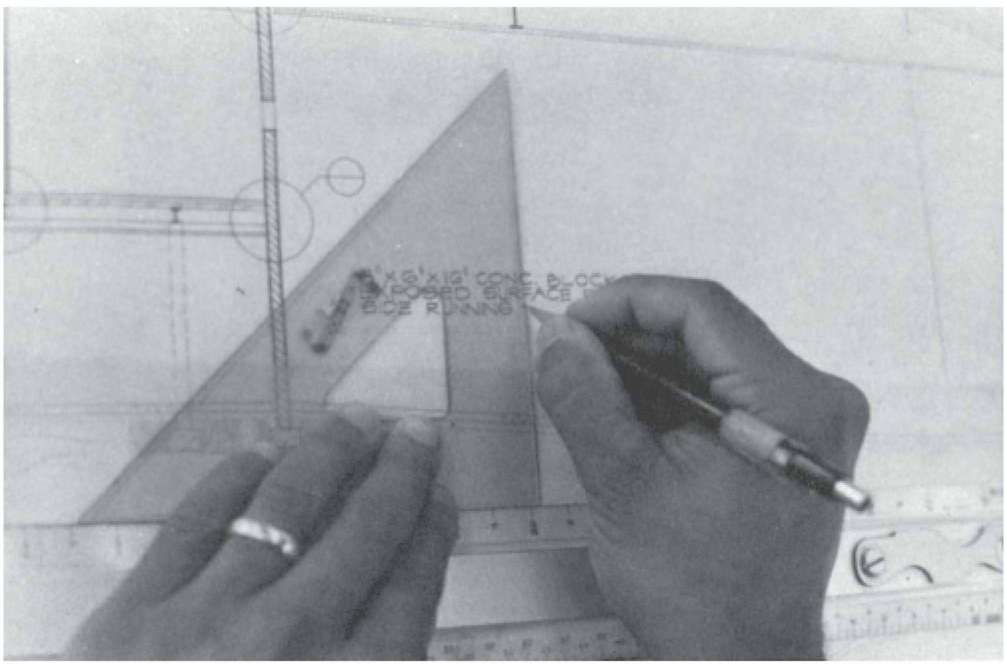


Figure 2.18 Placing the triangle against the pencil.

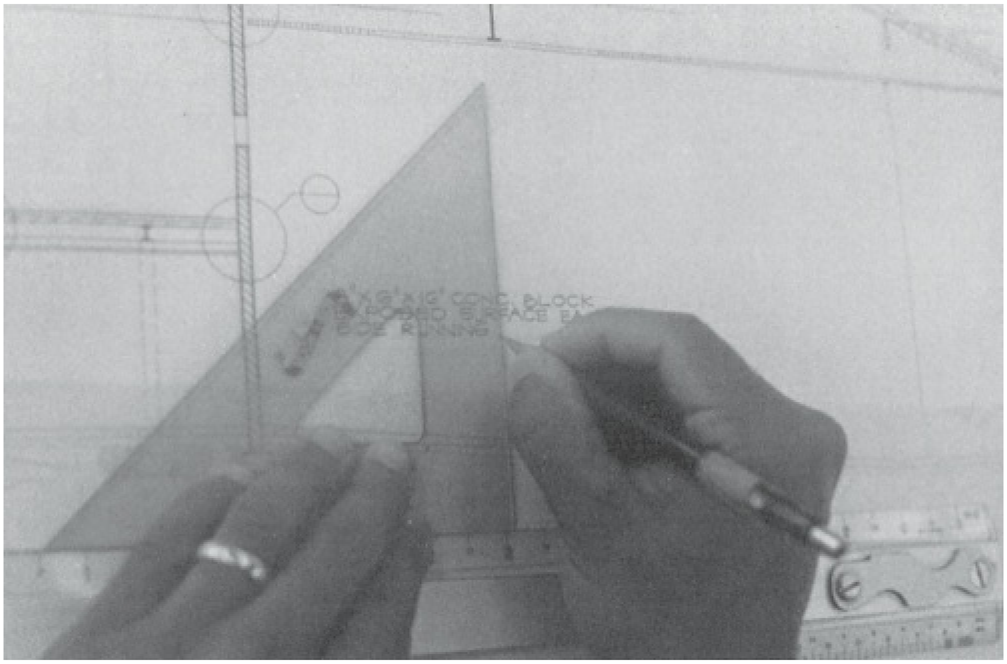


Figure 2.19 Drawing the vertical stroke.

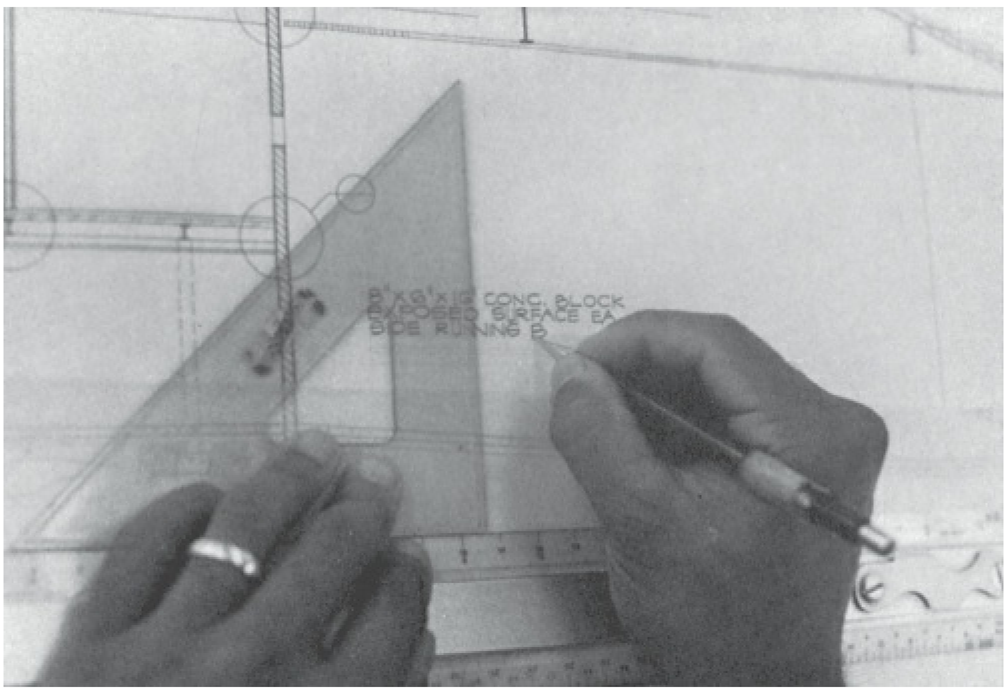


Figure 2.20 Completing the letter.

Using a straightedge helps build your skills. Eventually, you should discontinue its use as practice improves your lettering skills.

Drafting Conventions and Dimensions

Using Net and Nominal Sizing. Many architectural offices have adopted the practice of separating the **net size** and the **nominal size** of lumber in their notations. The *net size* is the size of the actual piece of wood drawn and used. The *nominal size* (call…out size) is used to describe or order a piece of lumber. For example, the nominal size of a "two by four" is 2 × 4, but the net or actual size is 1½″ × 3½″. The distinction between the two sizes is accomplished by the use of inch (″) marks. Figure 2.21A would be very

confusing because the nominal size is listed but inch marks are used. Compare this notation with that of Figure 2.21B. The 16″ o.c. (on center) is to be translated as precisely 16 inches, whereas the 2 × 4 is used to indicate nominal size.

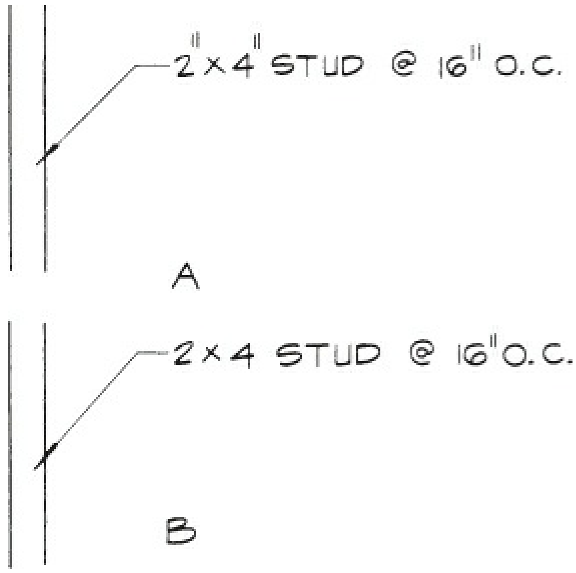


Figure 2.21 Net and nominal notation.

Dimensions. Dimensions in feet are normally expressed by a small mark to the upper right of a number (′), and inches by two small marks (″) in the same location. To separate feet from inches, a dash is used. See Figure 2.22. The dash in this type of dimensions becomes very important because it prevents dimensions from being misread and adds to clarity. If space for dimensions is restricted, an acceptable abbreviated form can be used. This is illustrated in Figure 2.23. The inches are raised and underlined to separate them from the feet notation.

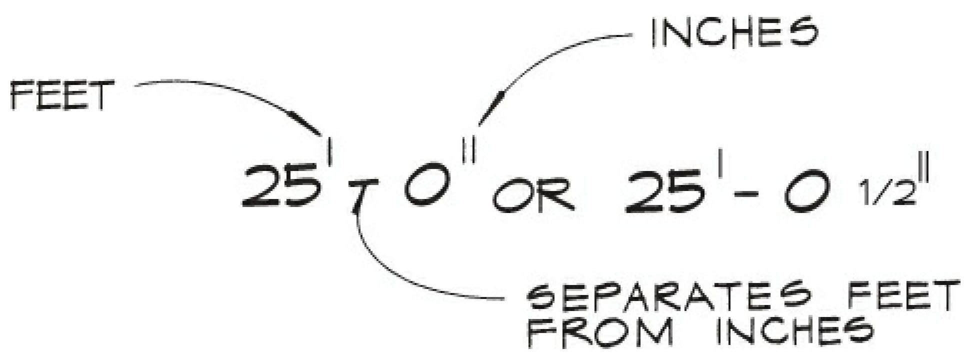


Figure 2.22 Expressing feet and inches.

Figure 2.23 Dimensions in a restricted area.

Placement of Dimensions. Dimension lines can be broken to show the numerical value, but it is faster simply to put numerical values above the lines. See Figure 2.24. When dimension lines run vertically, place the numbers above the dimension line as viewed from the right. See Figure 2.25.

Figure 2.24 Placement of dimensions above or between dimension lines.

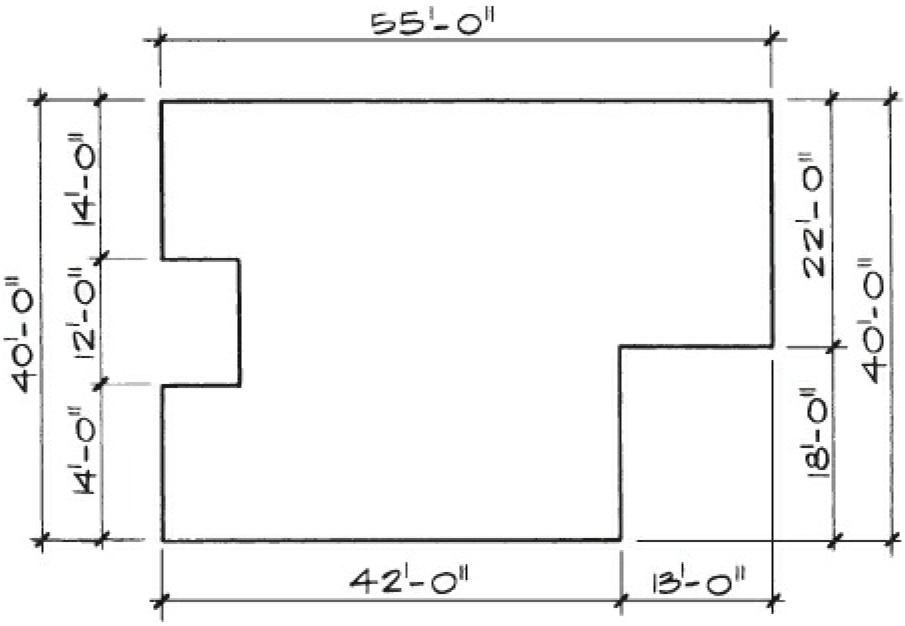


Figure 2.25 Dimensions read from bottom and from the right.

Not all dimension lines, however, are horizontal or vertical. Often, dimension lines are angled, and this can cause problems when you position the numerical value. Figure 2.26 suggests a possible location for such values.

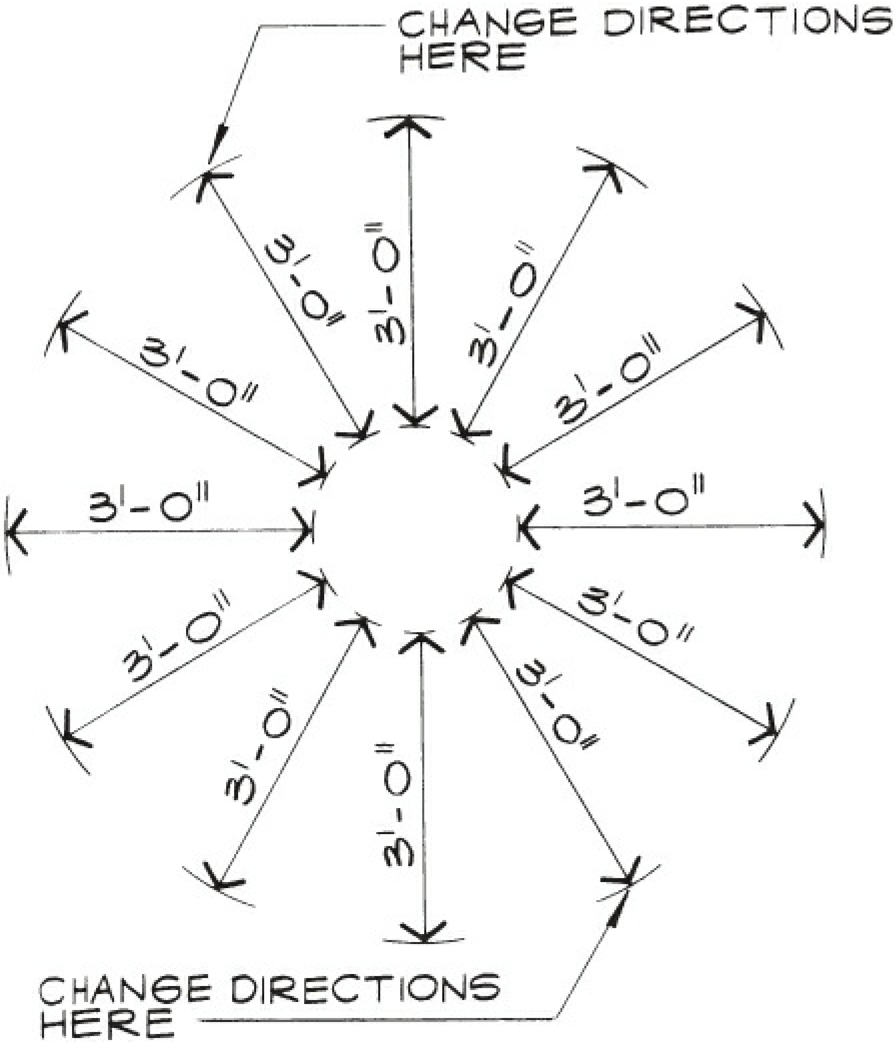
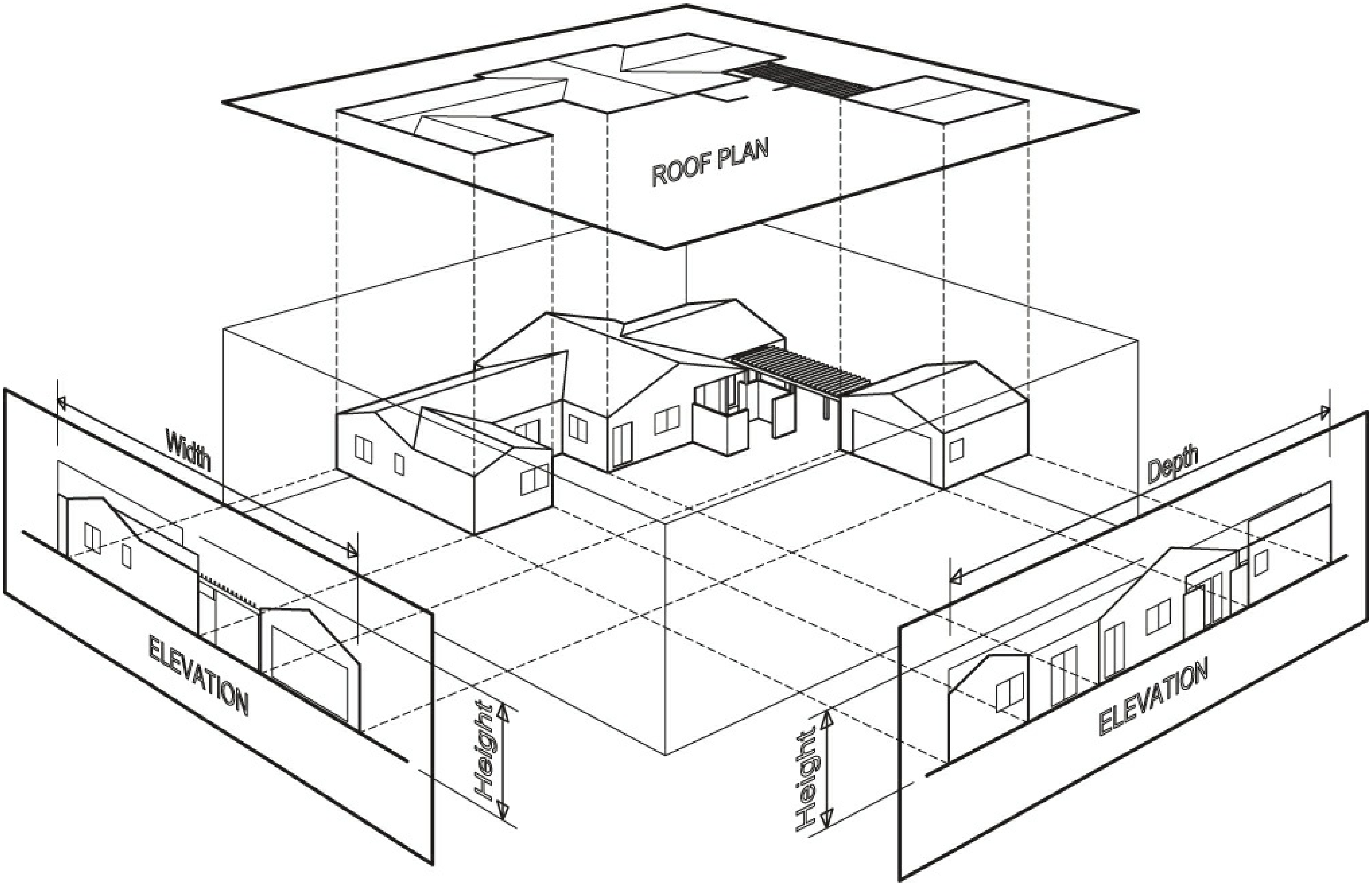


Figure 2.26 Dimension placement.

Architectural Drafting

The architectural version of **orthographic projection** is an object projected at 90° as you view the object, as shown in Figure 2.27. The top view (as viewed from a helicopter) is now called the *plan*, and the views all the way around from all four sides are referred to as **elevations.** Each of these elevations has a special name, as will be discussed in the chapter on exterior and interior elevations (Chapter 5).



[Figure 2.27](#) A multiview drawing of a structure.

In brief, a top view of the total property is called the **site** or **plot plan.** A horizontal section (drawn as if the structure were cut horizontally, the top portion removed, and the exposed interior viewed from above) is simply called a **plan.** There are many types of plans: **floor plans, electrical plans** (showing electrical features), **framing plans** (showing how a floor, ceiling, or roof is assembled), and **foundation plans,** to mention just a few.

A vertical cut through a structure is called a **cross‗section** or a **longitudinal section,** depending on the direction of the cut. The cross…section is a cut taken through the short end of a structure. As of the turn of the century (and for some architects), the architectural term for cross…section, longitude section transverse, has been replaced with the term **building section.**

Reproduction Methods

The Blueprint Process. In the first half of the twentieth century, the prevalent method of reproduction was the blueprint. **Blueprints** have a blue background and white lines. Bond paper was coated with light…sensitive chemicals, much like photographic film. The original, drawn on a translucent medium such as vellum, was placed over the paper and exposed to light. The light bleached out the chemicals except where they were screened

off by lines. The paper was then dipped in a developing solution that reacted with those sections not exposed to the light. The print was then washed and dried. As you can imagine, this process was time consuming. However, the lay public still uses the term *blueprint* to describe or refer to a copy of a drawing used in the building industry, even though these copies are now dark lines on a white background, most often made on a plain…paper copier.

Plain_Paper Copiers

Types and Sizes

A variety of plain…paper copiers are now on the open market for sale or lease. Some machines can enlarge as well as reduce. Some copiers do not copy the original to its exact size; instead, they change the size slightly and often in only one direction. Plain…paper copiers usually use the standard paper formats of 8½″ × 11″ and 8½″ × 14″. The larger copiers can take copy widths up to 54″, and length is unlimited, because these machines accept roll stock. Paper copiers can reproduce on bond paper, vellum, or acetate.

Appliques

Most adhesive films for plain…paper copiers have two sheets: one sheet of adhesive film and a backing sheet or carrier. Because the adhesive film has a sticky substance on one side, the carrier is a nonstick material. Standard decals or appliques can be made with adhesive film for things like symbols, title block information, and even construction notes.

Computer

The CAD systems are often combined with a printer or a plotter. A plotter can be used to reproduce a drawing and/or re…create a secondary original that can use the previously mentioned reproduction methods. The advantage is that you can change the size and scale of the reproduction instantly.

Because the industry is moving toward wireless units, both manufacturers and the computer industry are producing printers and plotters that can potentially be programmed directly to and from the computer. This promises to produce a flexibility heretofore unknown in the office to produce either single or multiple sets instantaneously.

A Very Special Observation by the Author. Having had the opportunity to be in attendance for many critiques as students presented their designs at state colleges, universities, private institutions, and even community colleges, I found that many of the drawings were not to the size they had expressed during their presentation. Students' presentations were interrupted, and they were asked if they realized the drawings were incorrect. When asked about this inaccuracy, every student replied, “It is accurate because I did it on the computer.” I asked the professors at the end of the critiques to allow me to

measure the drawings and found an error rate of up to 30% in one direction and 22% in the other direction.

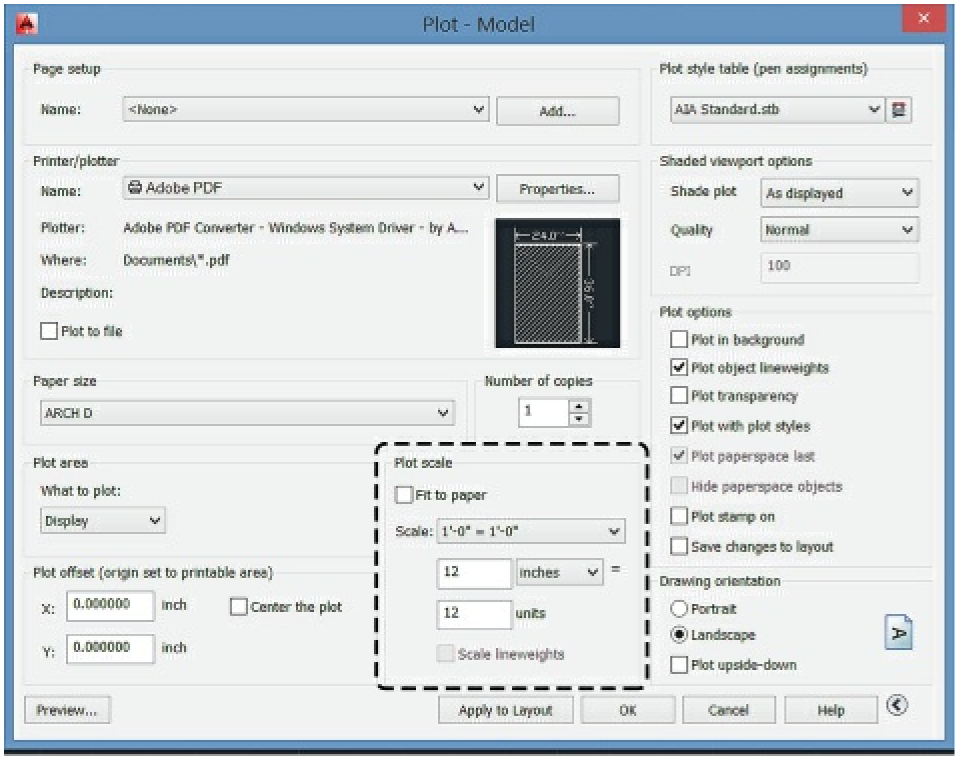
I brought this information back to my office and mathematically tried to solve this mystery. I found that the error was in 90% of the printers, as they were not correctly given the proper setting to produce a "one…to…one" copy.

It is important that your clients are shown the proper proportions of their structure, as clients are beginning to often have a very critical eye. Listed below are some suggestions that you can follow as a beginner in architecture to ensure properly scaled drawings that you will be able to present when you apply for employment and say with confidence, "Beyond what I just explained to you about my drawings, they will be accurate when printed."

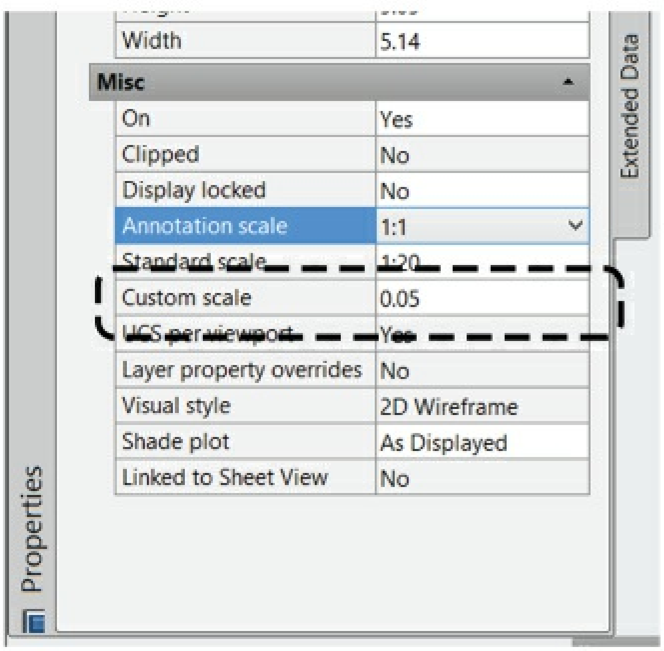
Printing to an Accurate Scale on AutoCAD

Step I. Draw your drawing in full scale on model space.

Step II. Go to paper space to set up your page. In this step you will be able to determine the paper size, printer, and plotting styles. See Figure 2.28A. You must choose your scale to be printed 1:1 to make sure it will print to scale. The scale will be determined on the viewport.



Ⓐ Page setup managemet (plot scale)



Ⓑ Properties tab (standard scale)

Figure 2.28 Printing to an accurate scale in AutoCAD.

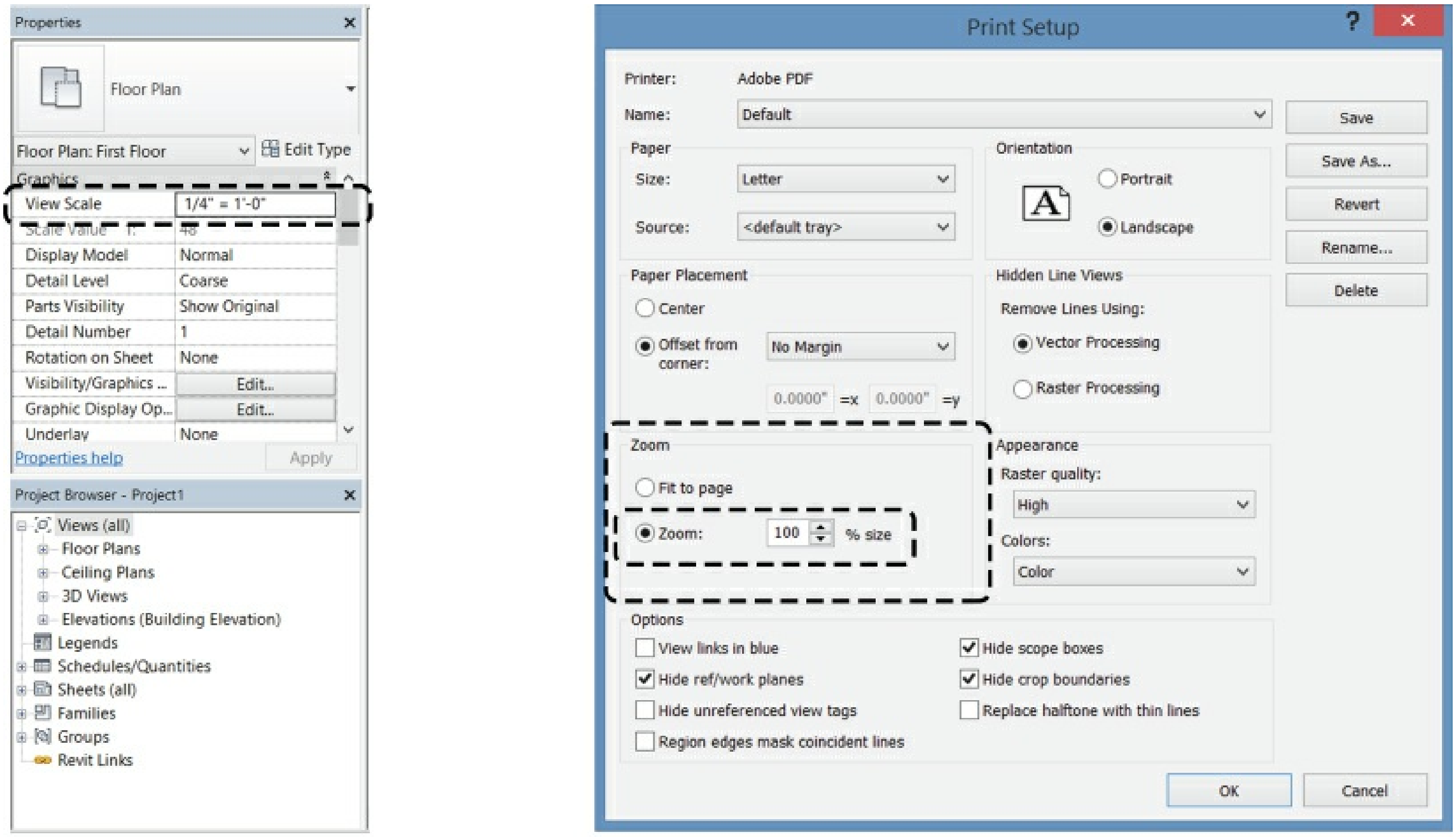
Step III. Once you have set up your page, you must create a viewport. The viewport will determine in which scale your drawing will be printed. Adjust your drawing to fit within this window and select your viewport; under the properties tab, select the scale you want to use. See Figure 2.28B.

Step IV. After all of the previous steps are done, you will be able to print to scale

make sure you print a test page and use your scale to measure a known dimension to confirm your drawing was printed to scale.

Printing to an Accurate Scale on Revit

Step I. Determine the scale you want your drawing to be printed on. If you will be printing at 1/4″ = 1′…0″, you will need to specify this on your Properties pallet. See Figure 2.29A.



A Properties Pallet **B** Print Setup

Figure 2.29 Printing to an accurate scale in Revit.

Step II. Under the application menu, select Print and a dialogue box will open. See Figure 2.29B. Under this dialogue box the most important part to select is the Setup Settings, and a second dialogue box will open. See step 3.

Step III. This is the most important portion while printing to make sure your drawing will be printed to scale. See Figure 2.29B. Under Zoom you MUST check zoom 100%. Your drawing will not print to scale if you check Fit to page. Under this dialogue box you can also select the paper size and paper placement. Please go to Chapter 15 for more detailed information on printing using Revit.

Step IV. Use your scale and measure to make sure your drawing printed to scale.

Shortcut Procedures

Freehand Drawing

One of the best shortcuts you can learn is freehand drawing. Most of the preliminary design procedures and conceptual design details in this book were done freehand. You still should use a scale to maintain accuracy and adhere to the drafting vocabulary of lines and techniques. Freehand skill is useful in field situations, for informal office communications, and for communications with contractors, building department officials, and clients.

Photography and Drafting

Photography plays a large part in architectural drafting. The older photographic method was used to produce a *photostat*. This technique is rapidly being replaced by the photomechanical transfer (PMT) system. In this process, there is no real negative. Rather, there is an intermediate paper negative that takes about 30 seconds to make; the image is then transferred from this throwaway master to a positive.

Still, the best—and the most versatile—process is regular camera photography. The only limit to the size of the print is the equipment itself, and 36″ × 42″ negatives are now available. Because negatives can be spliced together, the final limit is restricted only by the size of the positive paper available. Uses of photography are described later in this chapter.

Reprodrafting

Reprodrafting is a term used to describe a number of approaches to improving or revising drafted material in a way that takes advantage of photographic or photocopying processes. These approaches have spawned a number of new terms, including eraser drafting, paste…up drafting, photo drafting, overlay drafting, pen drafting, and scissors drafting. Reprodrafting, then, actually consists of many processes.

Restoration refers to the process of taking a photograph of an old original or an old print and, by repairing the negative, producing a new master.

Composite drafting is the photographic process of making a single drawing from many, or of taking parts of other drawings to make a new drawing.

Paste_up drafting simply refers to the process of pasting pieces onto a single master sheet, and then photographing and reproducing the master. The lines on the negative made by edges of the pieces can be eliminated by a photo retoucher.

Scissors drafting takes an existing drawing and eliminates undesirable or corrected portions by cutting them out before the paste…up process. **Eraser drafting** is similar, but the unwanted portions are simply erased. In both cases, the original is never touched. A good copy on good…quality paper is produced first. The copy must be printed in a way that allows easy erasure.

Photo drafting, as the name indicates, uses both drafting and photography. It begins with a photograph of any drawing, such as a plan, elevation, or detail. The drawing is printed on a matte…surfaced film, and additional information is drafted onto it. Photo drafting is an ideal method for dealing with historical restoration drawings.

Other Shortcut Methods

Using Standardized Sheets. Standardized sheets are useful if all the jobs an office takes are similar or if the office specializes in a particular building type that calls for the same information each time.

A Simple Shortcut: Manual Drafting

Make a copy of all the early stages of the different parts of a building. See Figure 2.30. The final drawing is shown in Figure 2.31. If there are no significant changes, tape the drawing to a piece of bond paper, copy it onto the vellum, and then finish the process. If, for example, the **pitch** (roof slope) is different, then simply cut out the roof portion, tape it to a sheet of bond paper, and print onto vellum. Manually correct the new roof pitch and proceed to finish the process.

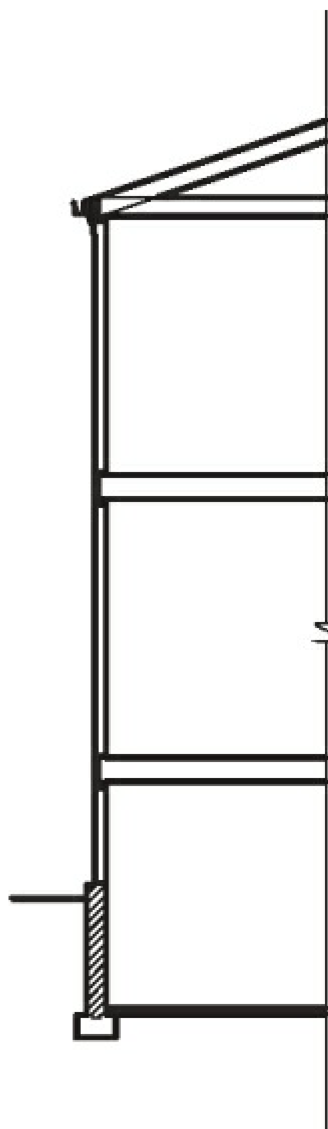


Figure 2.30 Save all earlier stages.

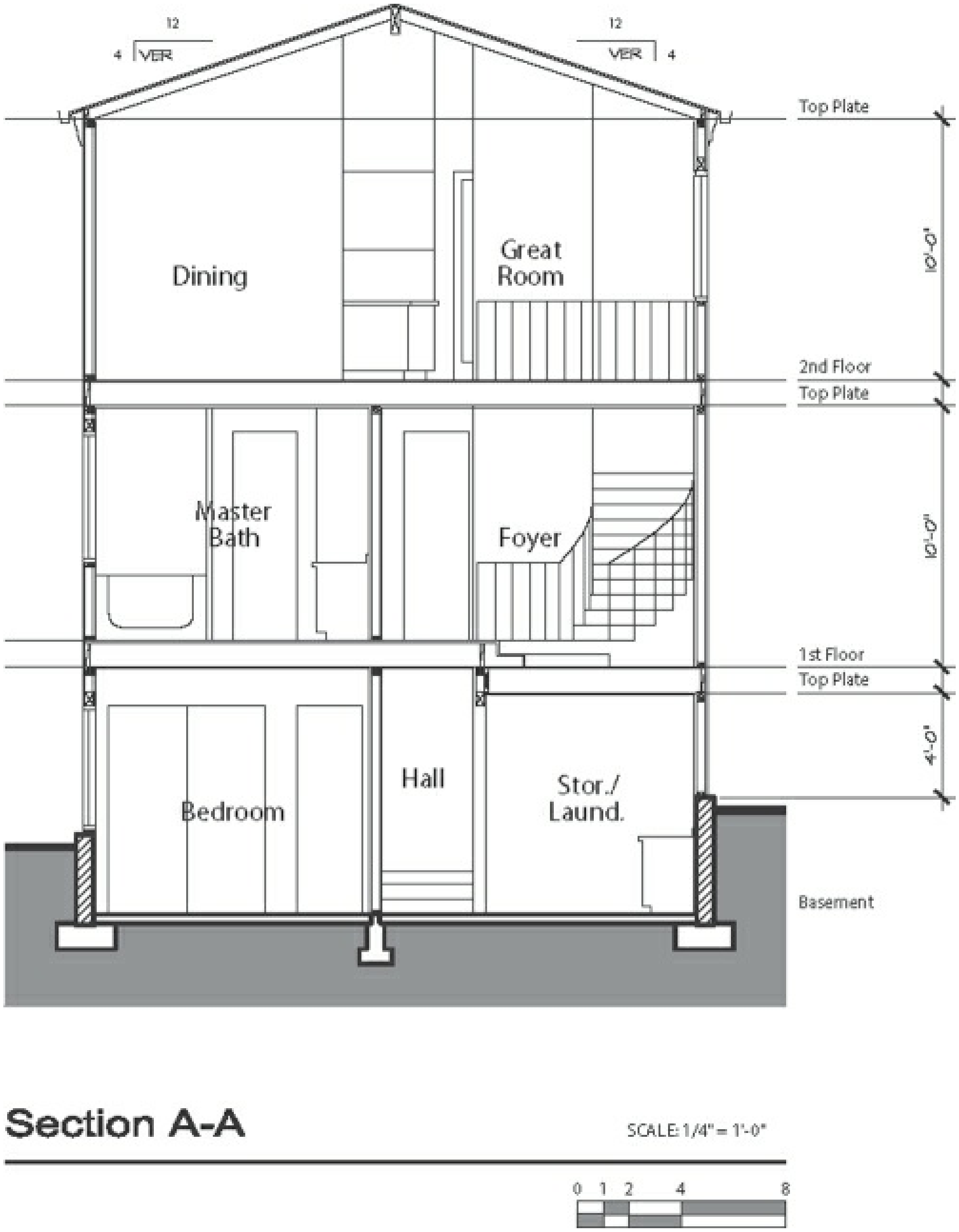
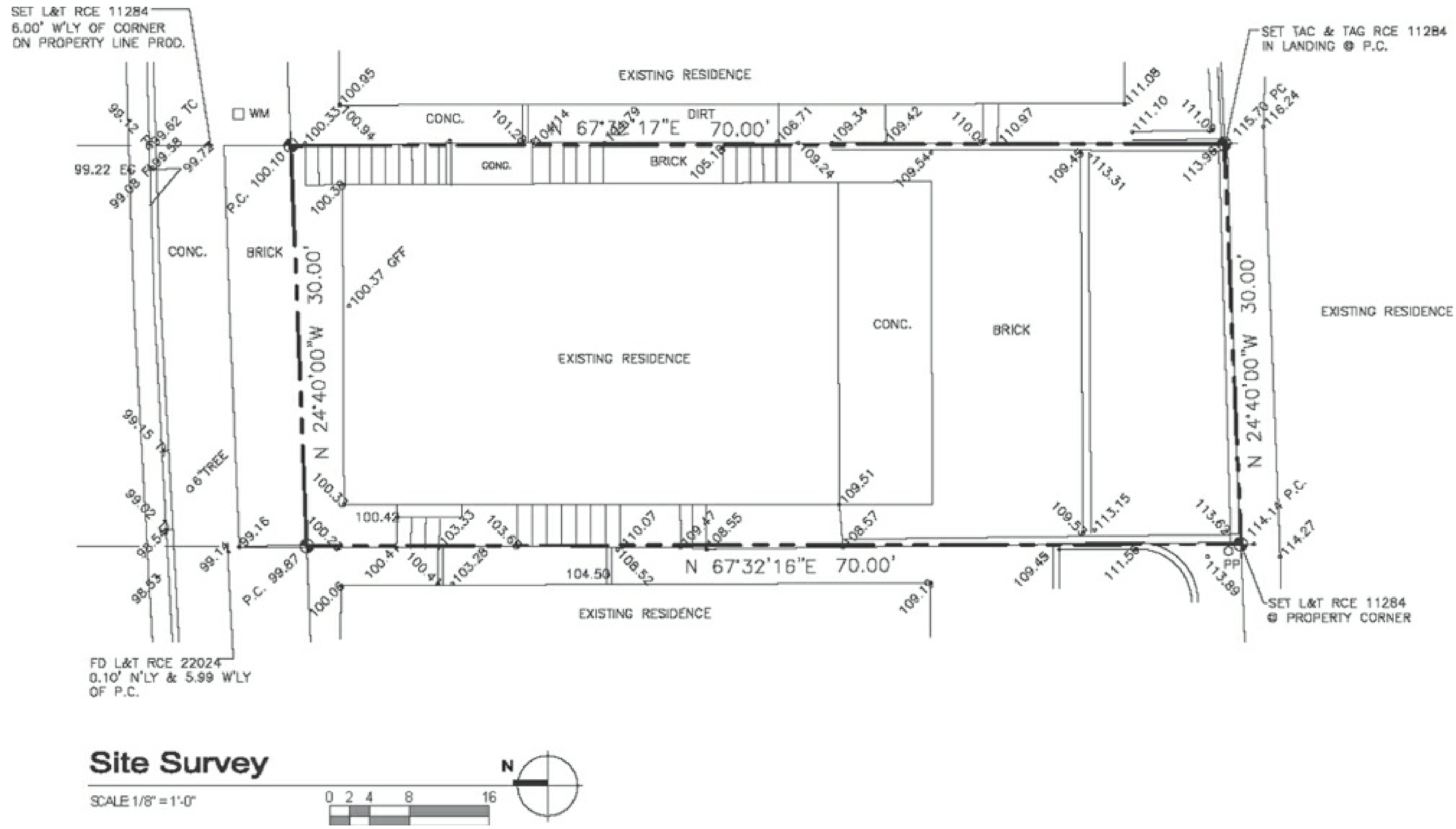


Figure 2.31 Using tracers.

A Much_Needed Survival Skill

Let us first set up a hypothetical problem and then apply a much…needed drafting skill:

Your task as a junior drafter in the office is to produce a workable floor plan and site plan that have been sent to you in a reduced format. The scale is unknown and is similar to that in Figure 2.32.



[Figure 2.32](#) Site plan and floor plan

The solution is to enlarge the drawing back to its original scale of ⅛″ = 1′…0″ for the site plan and ¼″ = 1′…0″ for the basement floor plan and print it on a 24″ × 36″ sheet of paper.

Manual Drafting Solution

Step I. *Establish a measurable datum*. For the site plan, it is a matter of taking one of the known measurements, such as the 70′ property line shown in [Figure 2.32](#). Redraw this measurement on a separate piece of paper at ⅛″= 1′…0″ scale. We will call this our *datum line*. See [Figure 2.33](#).

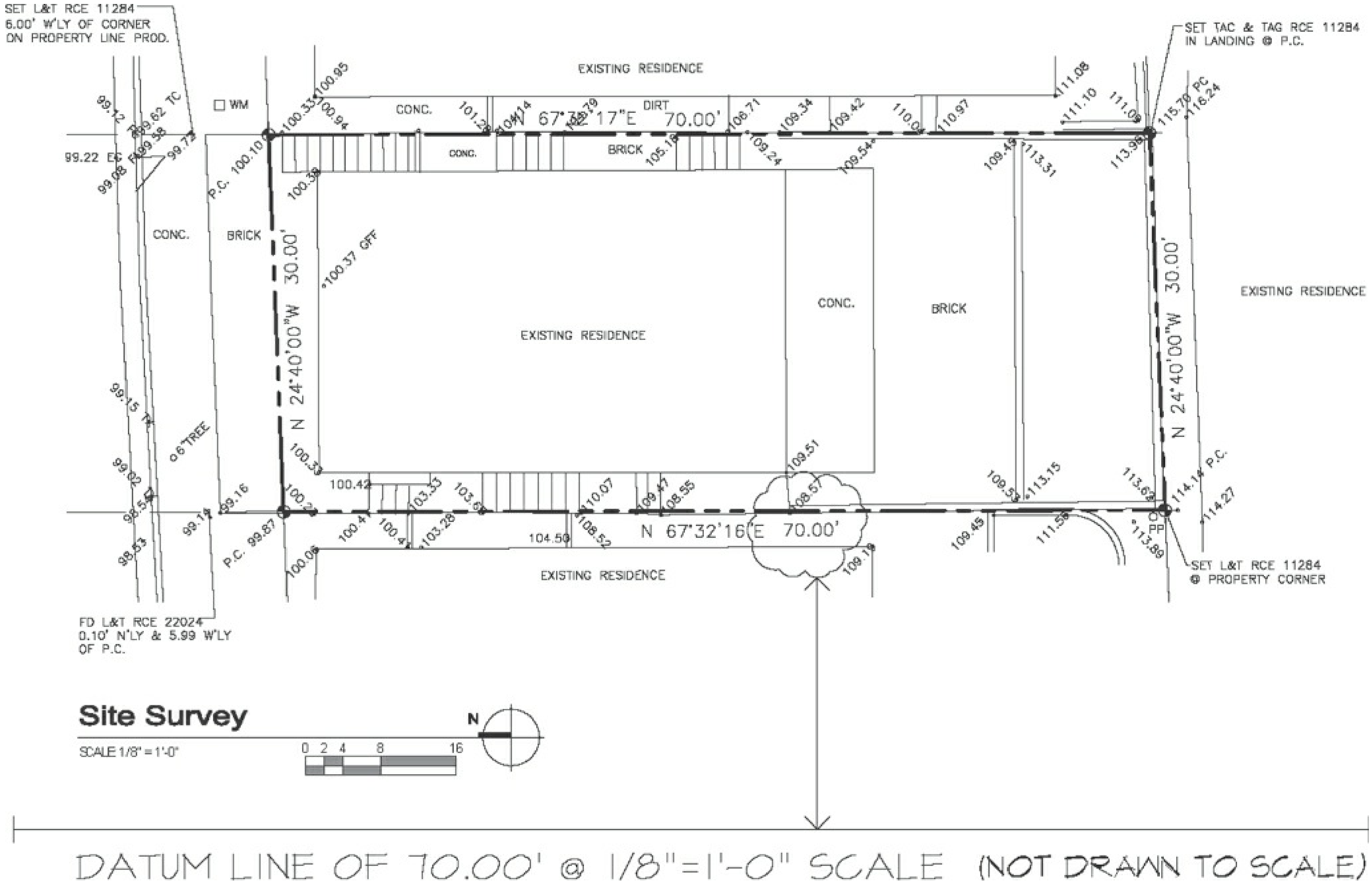


Figure 2.33 Establishing a 70′ datum at ⅛″ scale.

Step II. *Enlarge on the copier*. Enlarge the 70′ property line on the site plan to match the datum line. Do it based on an eyeball estimate.

Step III. *Compare the enlargement to the datum line*. Unless you are extremely lucky, the 70′ property line will not exactly match the datum line, so make either another enlargement or a reduction.

Step IV. *Adjust the enlargement*. You may find, as you get within 1%, that the 1% enlargement is just a bit too large. Try reducing the drawing by a small percentage, such as 5%, and then enlarge the drawing by 6%.

This enlargement calculation can also be done by a simple math ratio. Measure the N.T.S. (not to scale) 70′ line. Say it measures 56′, with ⅛″ being the desired scale: 70′/56′ × 100 = 125% enlargement.

Using a Computer

To achieve the enlargement using a computer, the first thing to do is to scan the image into the computer and import it into AutoCAD.

Step I. **Scan** the desired plan and **import** it into AutoCAD. Make sure that your AutoCAD at this time has been set up with the correct units and limits.

Step II. Select a known dimension on the drawing that you just scanned and create

a reference line. Now you will need to create a second reference line that is drawn to scale. You can now superimpose these two lines or bring them close together to change the scale. (It may be easier to identify if these two lines have different colors.) See Figure 2.34.

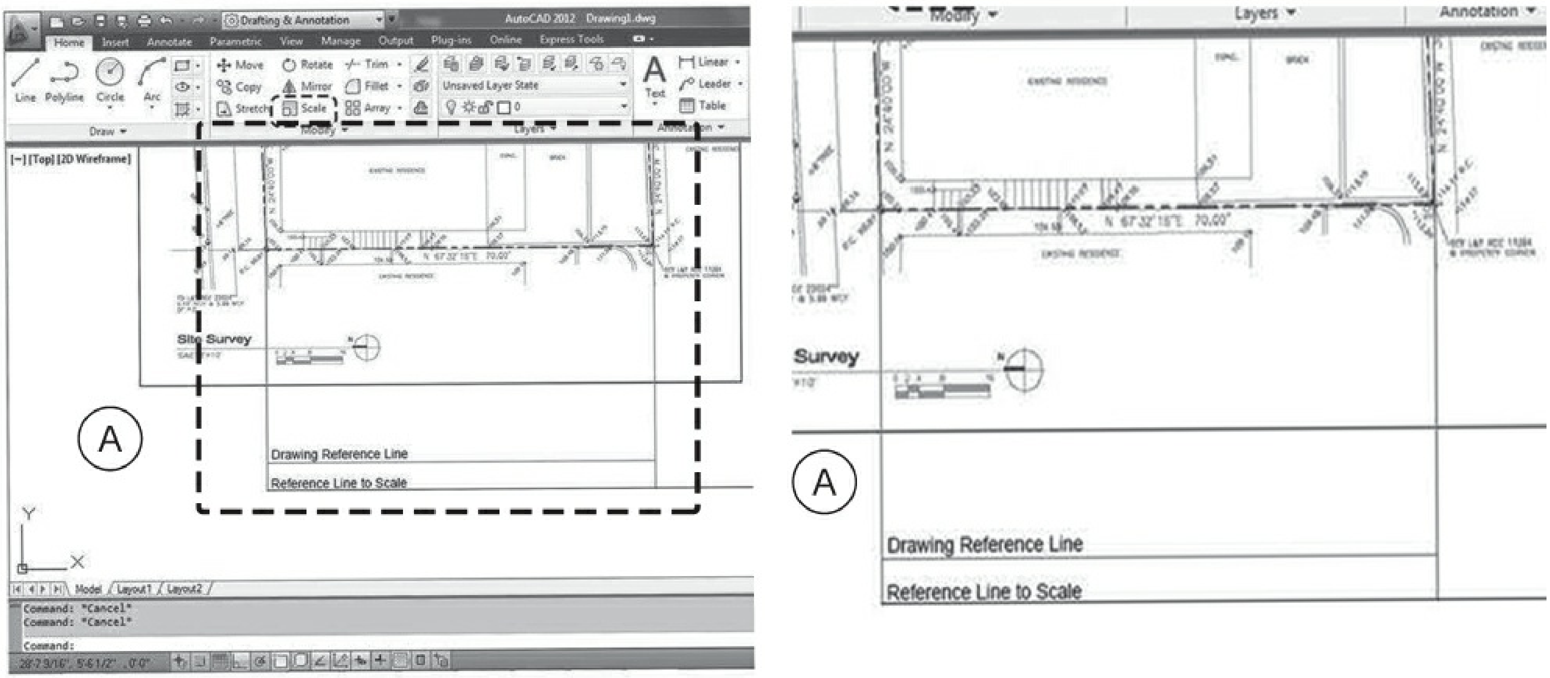


Figure 2.34 Using AutoCAD to scale a drawing.

Step III. Next go to the **Scale** command and select the drawing and the drawing reference line. Click on the end point of your scaled lined and type R for reference. Next, click the end point of the drawing reference line, and, finally, click the end point of the scale line. This will give you a scale drawing to be used in AutoCAD that can then be transferred to Revit if necessary.

Step IV. **Verify** by printing your drawing to scale and double…check that the dimensions are accurate.

OFFICE STANDARDS

Sheet Size

The drawing sheet size varies from office to office depending on the type of work performed, size of the job, and the system of drafting used in the office. The most common sheet sizes are 24″ × 36″, 30″ × 42″, and 36″ × 48″.

When sheets are used horizontally, they are usually bound on the left side. Because of this, the border is larger on the left side. A typical border line is 3⁄8″ to ½″ around the three sides and 1″ to 1½″ on the left side.

Title blocks can run the full height of the right side rather than simply filling a square in the bottom right corner, as in mechanical drafting. The long title band contains such

information as sheet number, client's name or project title, name of firm, name or title of the drawing, person drafting, scale, date, and revision dates. The title block sheets are usually preprinted, but can be applied to sheets in the form of decals or appliques.

This location of the title block allows you to leave a rectangular area for drawing purposes, whereas a title block in the lower right corner produces an L…shaped drawing area. (Even when drawing on a large sheet, take care to draft so that you use the sheet to its fullest.)

Many offices establish a sheet module. Here is an example of this method with a 24″ × 36″ sheet:

Binding side	1½″ border
Other three sides	½″ border
Title block	1½″

This leaves a drawing area of 23″ by 32½″. The vertical 23″ distance can be divided into four equal parts, while the horizontal 32½″ can be divided into eight equal parts. This provides 32 spaces 41⁄16″ wide by 3⁄4” high. This office procedure may be followed so that each sheet has a consistent appearance. Whether the sheet is full of details or a combination of a plan and details and/or notes, the module gives you parameters within which to work. You should draft from the right side of the sheet so that any blank spaces remaining are toward the inside (on the binding side).

Lettering Height

The height of lettering depends on the type of reproduction used. If you use normal diazo methods, use the following standards as a rule of thumb:

Main titles under drawings	1⁄4” maximum
Subtitles	3⁄16″
Normal lettering	3⁄32″– ⅛″
Sheet number in title block	½″–1″

Increase these sizes when you are reducing drawings. For example, increase normal lettering from 3⁄32″ to 3⁄16″, depending on the reduction ratio.

Lettering. One of the most important office standards to which a drafter must subscribe is lettering. Many offices use a combination of uppercase and lowercase letters for the main titles, such as for room names. Certain fonts, such as Helvetica and Garamond, are very popular. When selecting a font, be sure to find one based on a simple stroking system so as not to impede the printing process. There can be a marked difference in the printing or plotting time for different fonts, especially when the text is very long, as in general notes, framing notes, or energy notes.

The height of the letters is also very important for legibility. Lettering that is ⅛″ or 3⁄32″

tall is very readable. Using letters 1⁄4″ tall (maximum) for main titles produces enough contrast between notes and titles to enhance the construction documents.

In general, we suggest an architectural font. It speeds up the correction process. See “Importance of Hand Lettering,” discussed earlier in this chapter.

A problem caused by the infusion of electronic equipment into our field is the difficulty in maintaining the lettering size on drawings that are electronically reduced either on a plain…paper copier or digitally on a computer.

Scale of Drawings

The scale selected should be the largest practical scale based on the size of the structure and the drawing space available. The following are the sizes most commonly used by offices, with the most desirable size being underlined where there is a choice.

Site Plan: 1⁄8″ = 1′…0″ for small sites. Drawings are provided by a civil engineer and scales are expressed in engineering terms such as 1″ = 10′, 1″ = 20′, etc.

Floor Plan: 1⁄4″ = 1′…0″, 1⁄8″ or 1⁄16″ = 1′…0″ for larger structures.

Exterior Elevations: Same as the floor plan.

Building Sections: 1⁄4″ = 1′…0″; 1⁄2″ = 1′…0″ for smaller projects.

Interior Elevations: 1⁄4″ = 1′…0″, 3⁄8″ = 1′…0″, 1⁄2″ = 1′…0″.

Architectural Details: 1⁄2″ = 1′…0″ to 3″ = 1′…0″, depending on the size of the object being drawn or the amount of information that must be shown. Footing detail: 3⁄4″ = 1′…0″ or 1″ = 1′…0″. Eave details: 1½″ = 1′…0″. Wall sections: typically 3⁄4″ = 1′…0″.

Materials in Section

Figure 2.35 shows the various methods used throughout the United States to represent different materials in section. These conventions were developed by the Committee on Office Practice, American Institute of Architects (National), and published in **Architectural Graphic Standards**.

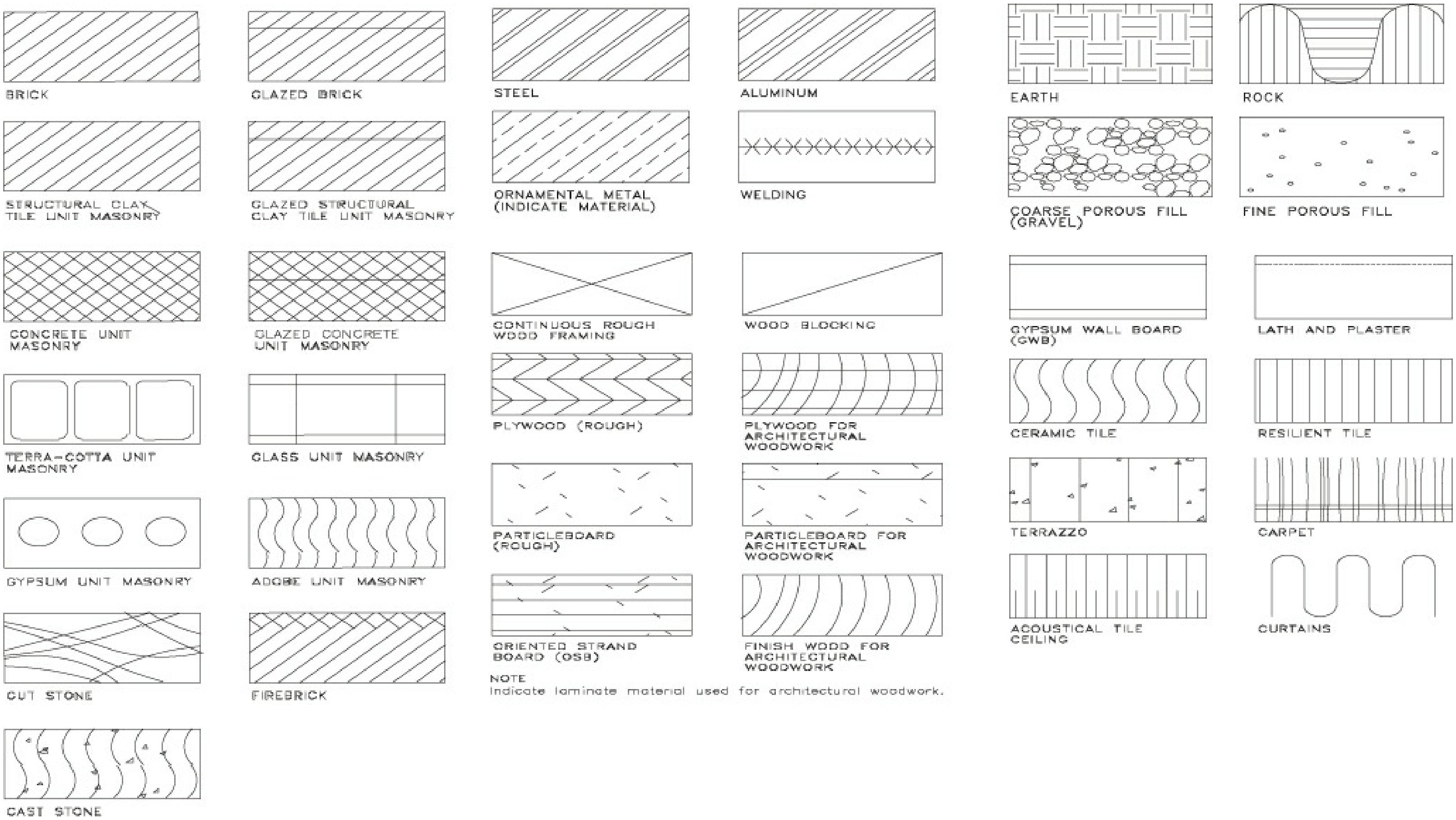


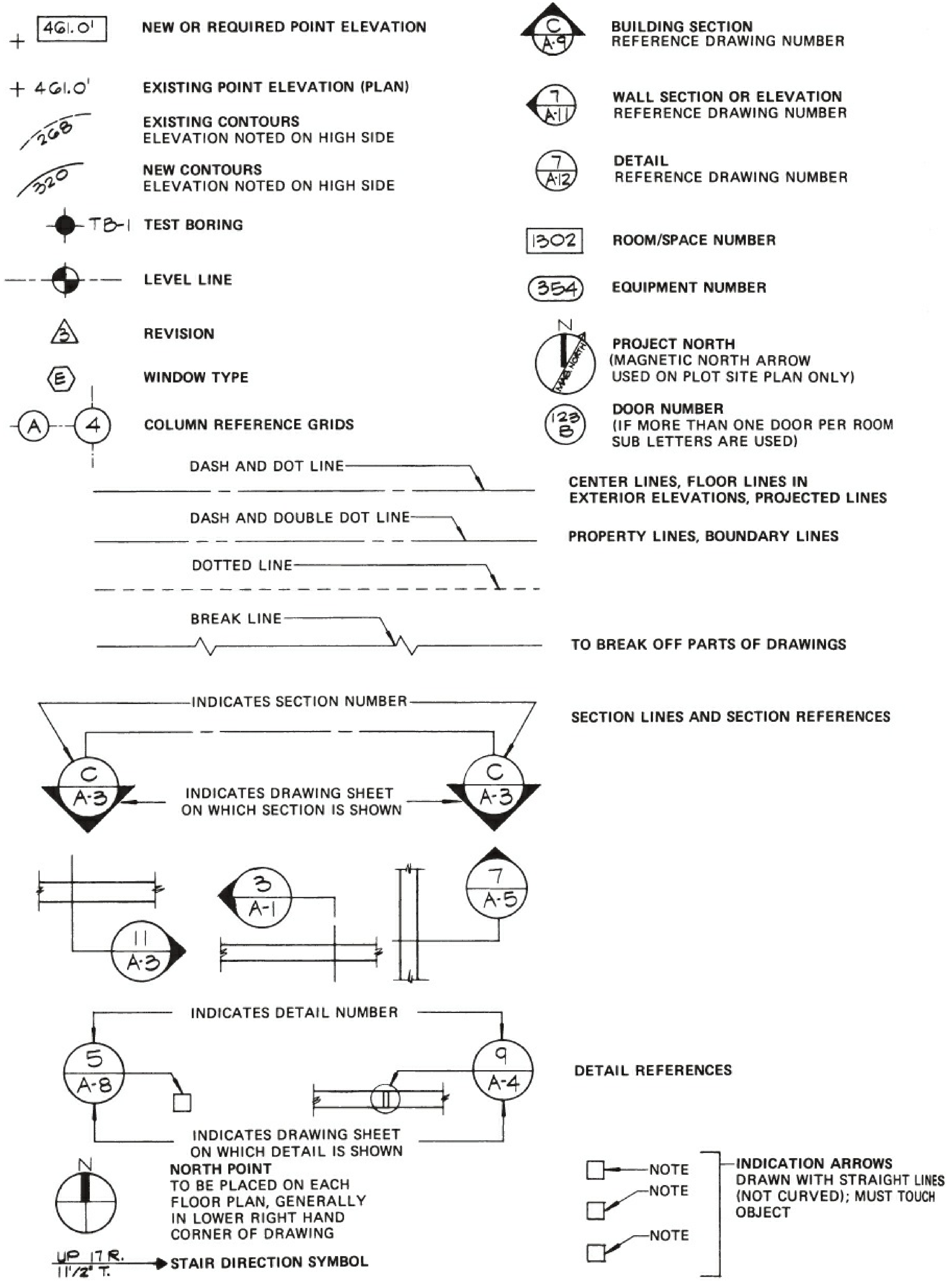
Figure 2.35 Graphic symbols for materials in section.

(Hoke 2000. Reprinted by permission from *The Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

Clearly, there is standardization and there are variations. For example, all groups agree on the method of representing brick in section, yet there is a great deal of variation in the way concrete block is represented in section. The last figure shows specialty items from a variety of sources.

Graphic Symbols

The symbols in Figure 2.36 are the most common and acceptable, to judge by the frequency with which the architectural offices surveyed use them. This list can be and should be expanded by each office to include those symbols generally used in its practice and not indicated here.



461.0'
NEW OR REQUIRED POINT ELEVATION
+ 461.0'
EXISTING POINT ELEVATION (PLAN)
268
EXISTING CONTOURS
ELEVATION NOTED ON HIGH SIDE
320
NEW CONTOURS
ELEVATION NOTED ON HIGH SIDE
TB-1
TEST BORING
LEVEL LINE
3
REVISION
E
WINDOW TYPE
A
4
COLUMN REFERENCE GRIDS
C
A-9
BUILDING SECTION
REFERENCE DRAWING NUMBER
7
A-11
WALL SECTION OR ELEVATION
REFERENCE DRAWING NUMBER
7
A-12
DETAIL
REFERENCE DRAWING NUMBER
1302
ROOM/SPACE NUMBER
354
EQUIPMENT NUMBER
N
MAG NORTH
PROJECT NORTH
(MAGNETIC NORTH ARROW
USED ON PLOT SITE PLAN ONLY)
123
B
DOOR NUMBER
(IF MORE THAN ONE DOOR PER ROOM
SUB LETTERS ARE USED)
DASH AND DOT LINE
CENTER LINES, FLOOR LINES IN
EXTERIOR ELEVATIONS, PROJECTED LINES
DASH AND DOUBLE DOT LINE
PROPERTY LINES, BOUNDARY LINES
DOTTED LINE
BREAK LINE
TO BREAK OFF PARTS OF DRAWINGS
INDICATES SECTION NUMBER
SECTION LINES AND SECTION REFERENCES
C
A-3
INDICATES DRAWING SHEET
ON WHICH SECTION IS SHOWN
C
A-3
3
A-1
7
A-5
11
A-3
INDICATES DETAIL NUMBER
5
A-8
11
9
A-4
DETAIL REFERENCES
INDICATES DRAWING SHEET
ON WHICH DETAIL IS SHOWN
N
NORTH POINT
TO BE PLACED ON EACH
FLOOR PLAN, GENERALLY
IN LOWER RIGHT HAND
CORNER OF DRAWING
NOTE
NOTE
NOTE
INDICATION ARROWS
DRAWN WITH STRAIGHT LINES
(NOT CURVED); MUST TOUCH
OBJECT
UP 17 R.
11'/2" T.
STAIR DIRECTION SYMBOL

Figure 2.36 Graphic symbols from AIA standards.

Abbreviations

Suggested abbreviations compiled by Task Force #1, National Committee on Office Practice, American Institute of Architects, and published in the AIA *Journal,* can be found in Appendix C on the web site www.wiley.com/go/wakita.

Dimensioning

Dimensioning is the act of incorporating numerical values into a drawing as a means of sizing various components and also locating parts of a building. This is accomplished on dimension lines, in notes, and by reference to other drawings or details.

Grouping Dimensions

Group dimensions whenever possible, in order to provide continuity. This takes planning. Try running a print of the drawing in question and dimension it on this check print first. This will allow you to identify dimensions and decide how they can be effectively grouped.

Maintaining a Dimension Standard

The most important dimensions dictate subsequent dimensions. For example, if a wall is dimensioned to the center of the wall first, all subsequent dimensions using this wall as a reference point should be dimensioned at its center.

Size Dimensions and Location Dimensions

The two basic kinds of dimensions are size and location. See Figure 2.37. Size dimensions indicate overall size. Location dimensions deal with the actual placement of an object or structure, such as a wall, a window, or a planter.

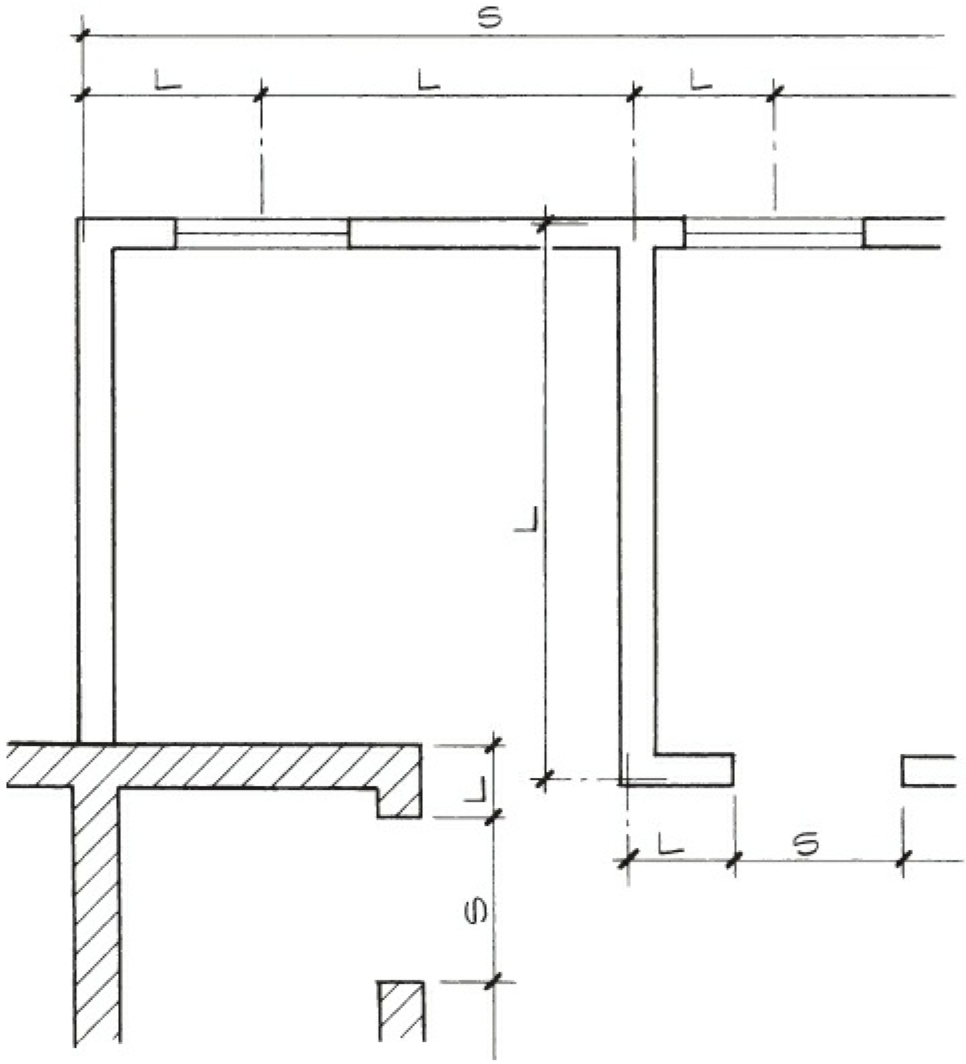


Figure 2.37 Size and location dimensions.

THE DIMENSIONAL REFERENCE SYSTEM

The **Dimensional Reference System** is based on a three…dimensional axis. See Figure 2.38. Critical planes are located by a series of reference bubbles and used as **planes of reference.** Figure 2.39 shows a box; reference bubbles describe the three planes of height, width, and depth. Now examine this box sliced in two directions, as shown in Figures 2.40 and 2.41. The first slice produces a **horizontal control plane,** and the second a **vertical control plane.**

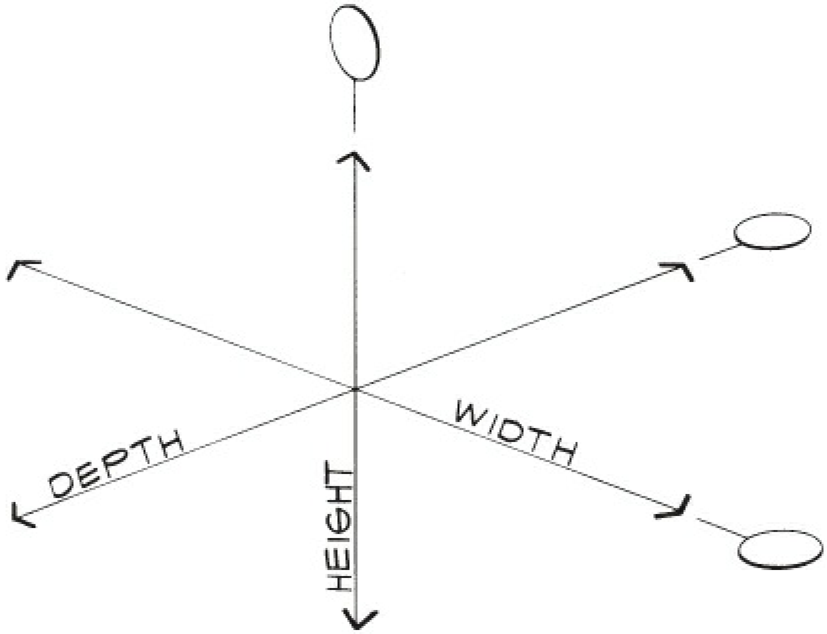


Figure 2.38 Dimensional reference system.

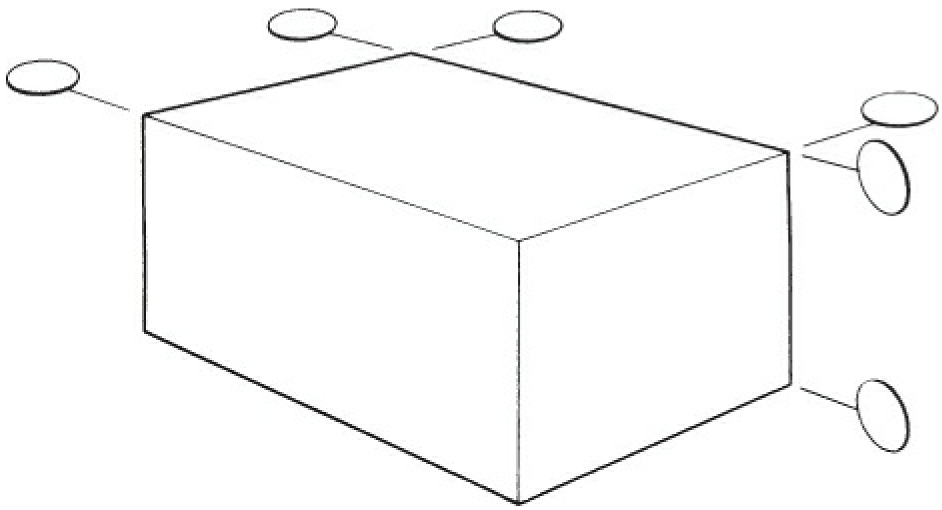


Figure 2.39 Three principal planes using dimensional reference system.

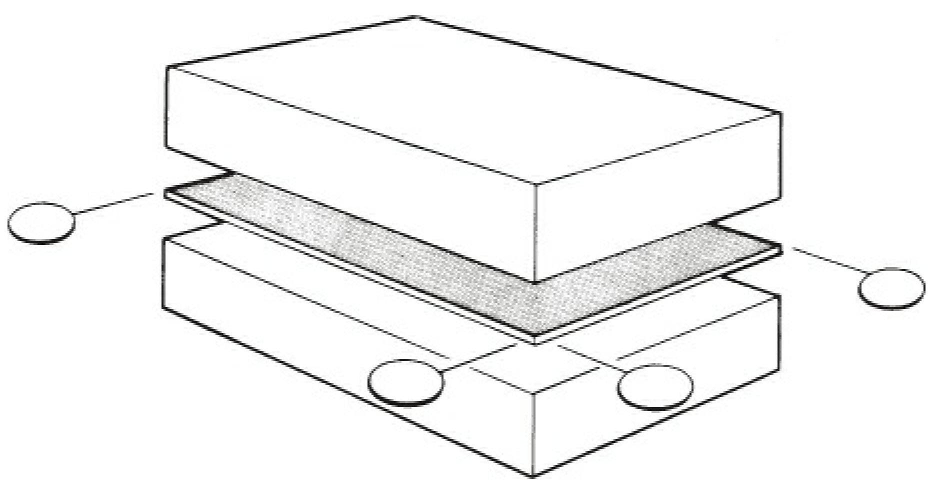


Figure 2.40 Horizontal control plane.

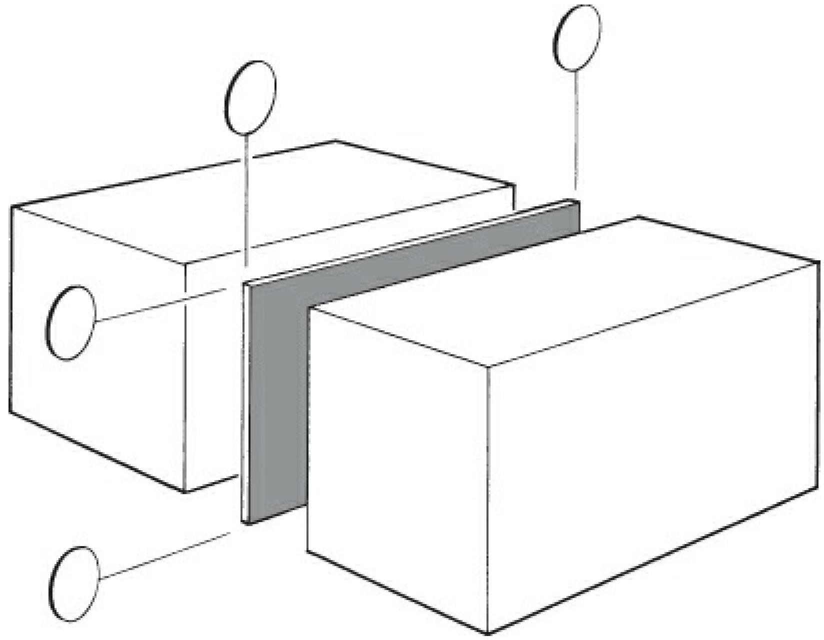


Figure 2.41 Vertical control plane.

The shaded area in Figure 2.42 represents a horizontal plane at a critical point on the structure, such as the floor line. The shaded area in Figure 2.43 represents a vertical plane at a critical point of the structure, such as the location of a series of columns or beams. There is a definite relationship between the vertical control plane and the horizontal control plane. Compare the plan and the section shown in Figure 2.44. The section is a vertical cut as in Figure 2.40 and the plan is a horizontal cut as in Figure 2.42. The two vertical and one horizontal reference bubbles on Figure 2.42 are an attempt to show this relationship.

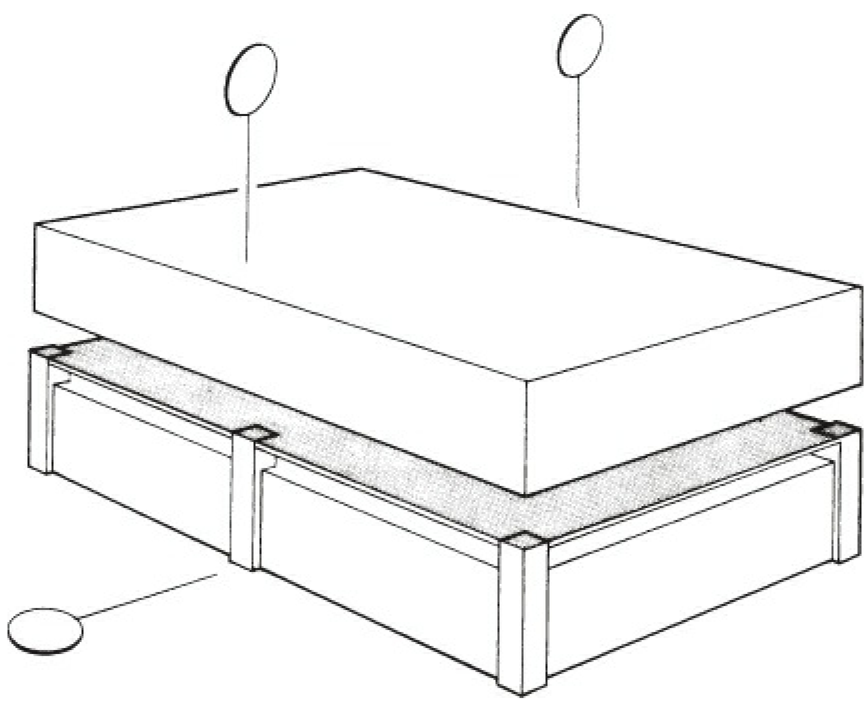


Figure 2.42 Horizontal plane.

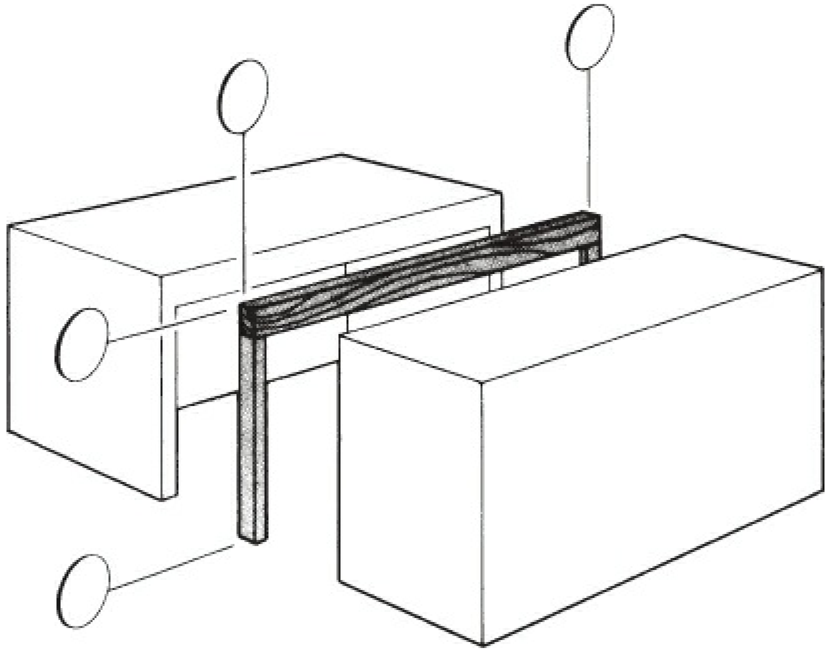


Figure 2.43 Vertical plane.

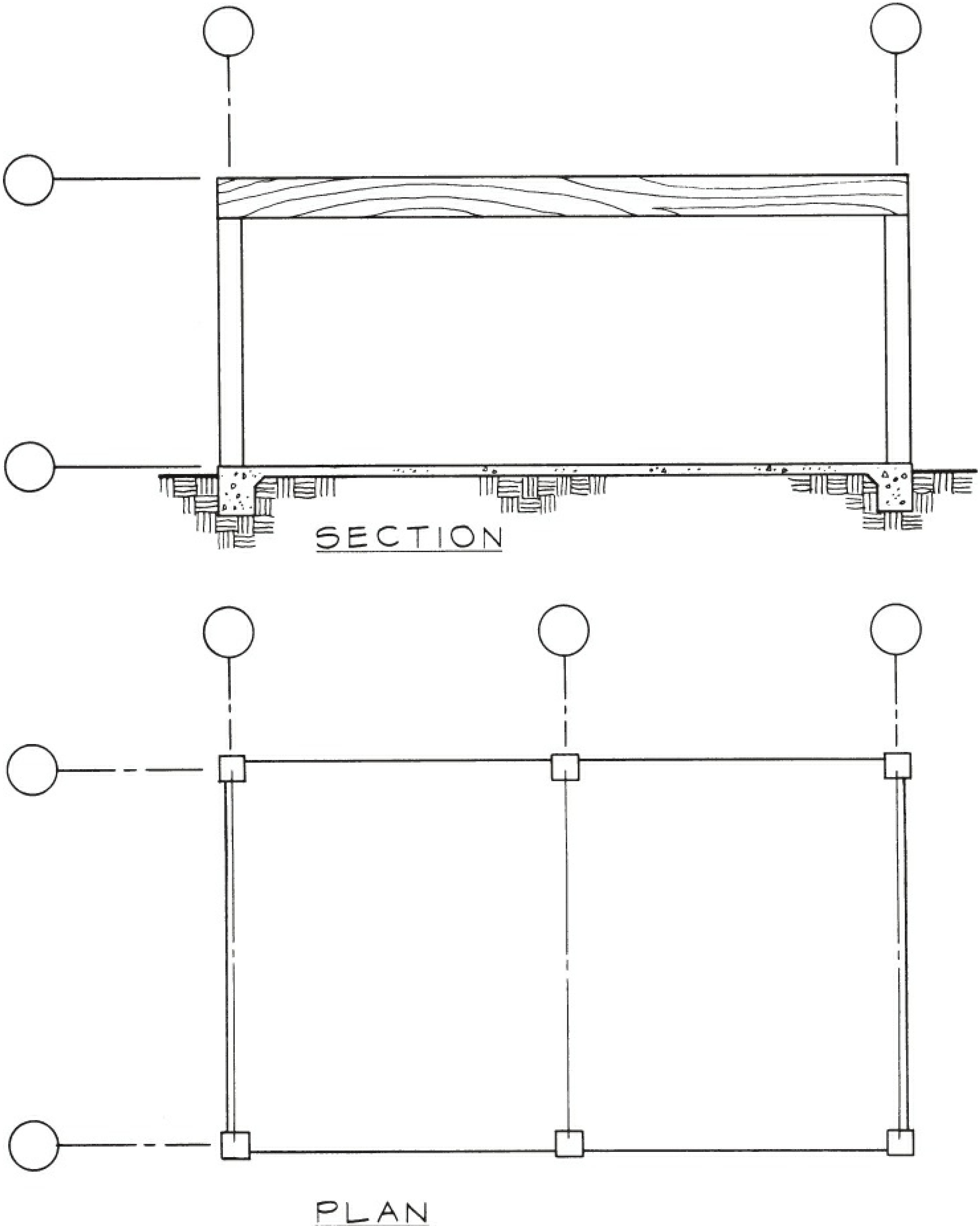


Figure 2.44 Section and plan.

Types of Planes

There are two types of planes. The first is the **axial plane,** which goes through the center of critical structural items as shown in Figure 2.45. Note how the columns are dimensioned to the center. When **pilasters** (widening of a masonry wall for support) are used, they become a good location for control dimensions, as they support the structural members above.

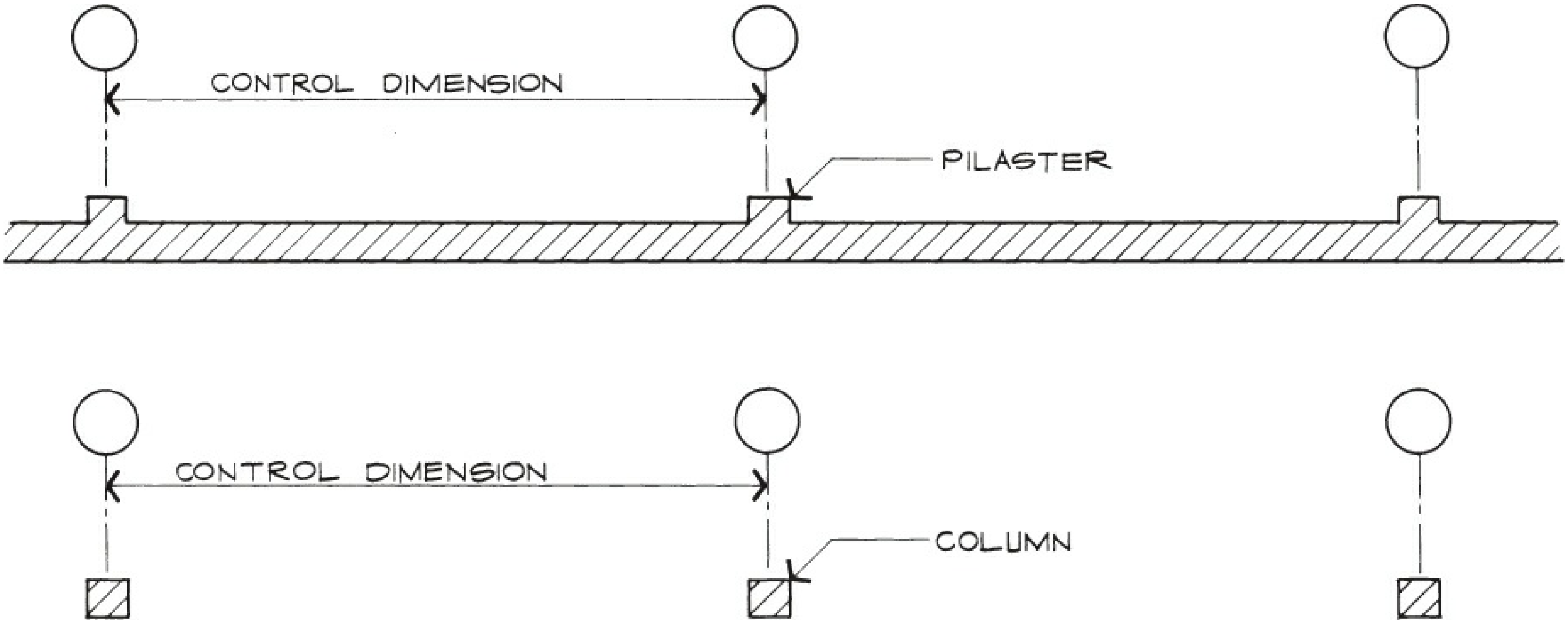


Figure 2.45 Axial control planes.

The second type of plane is called a **boundary control plane.** See Figure 2.46. In this case, columns and walls are not dimensioned to the center; instead, their boundaries are dimensioned. Figure 2.47 shows examples of columns and walls located in the **neutral zone.** These neutral zones are especially valuable in dealing with the vertical dimensions of a section and with elevations. See Figure 2.48. A neutral zone is established between the ceiling and the floor above. The floor…to…ceiling heights can be established to allow the structural, mechanical, and electrical consultants to perform their work. Once that dimension is established, the neutral zone and floor…to…floor dimensions follow. See Figure 2.49 for a practical application for the **vertical control dimension** and **control zone** (another term for neutral zone).

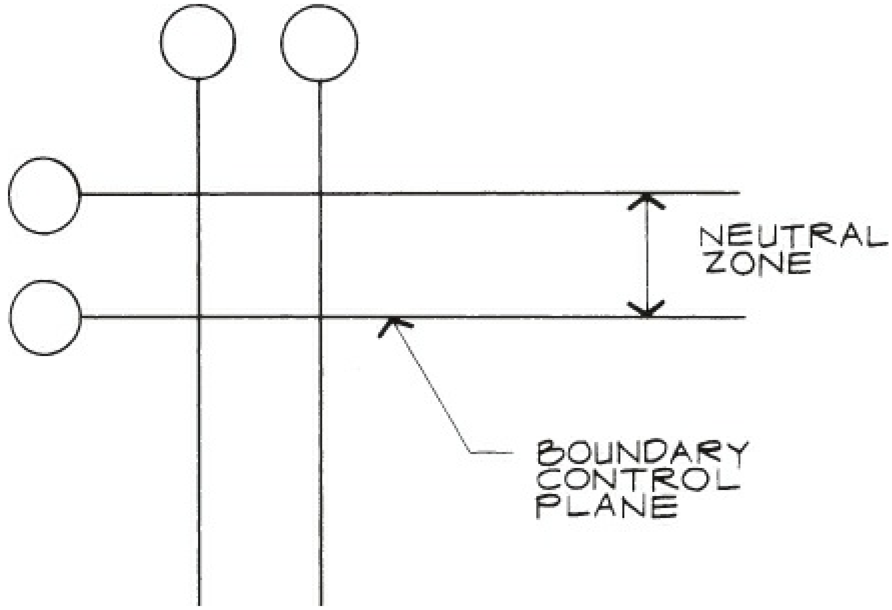


Figure 2.46 Boundary control planes.

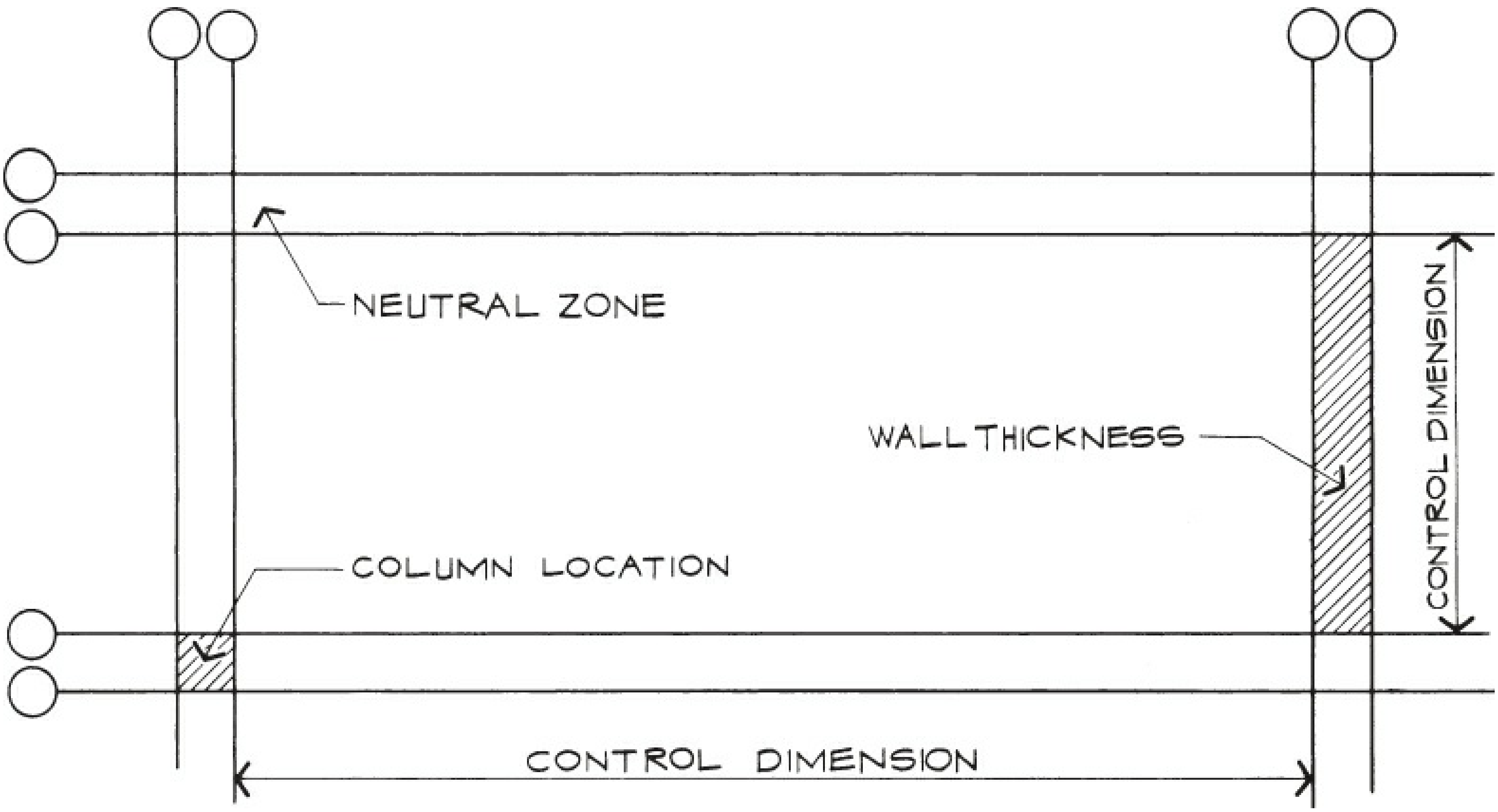
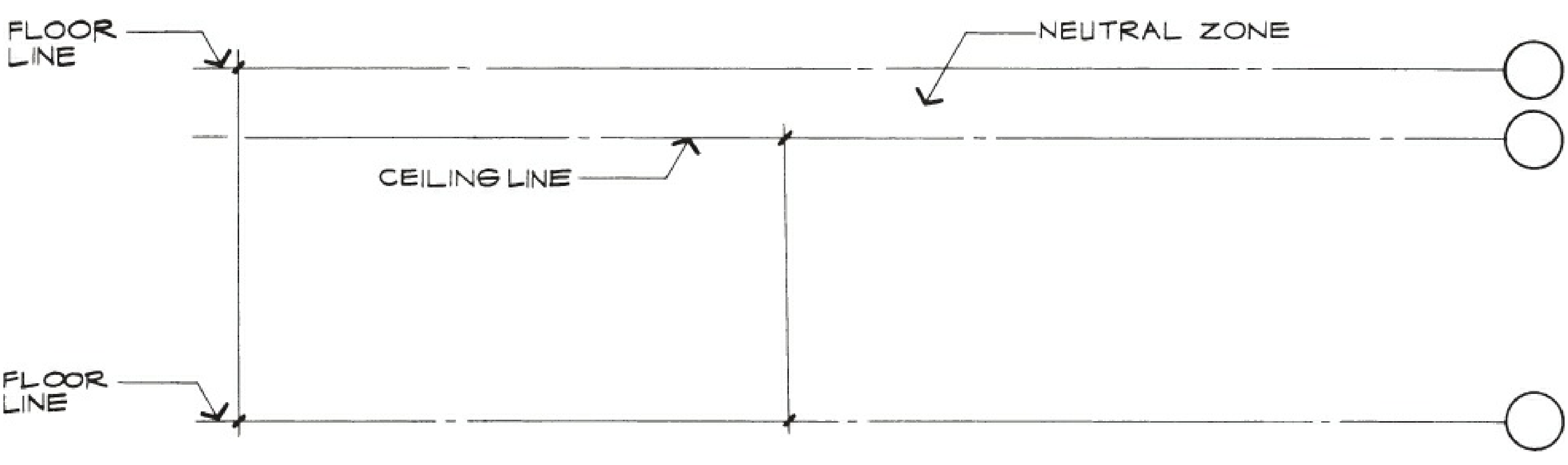
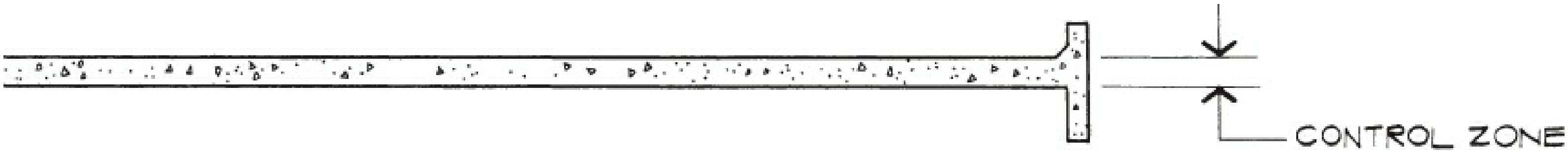
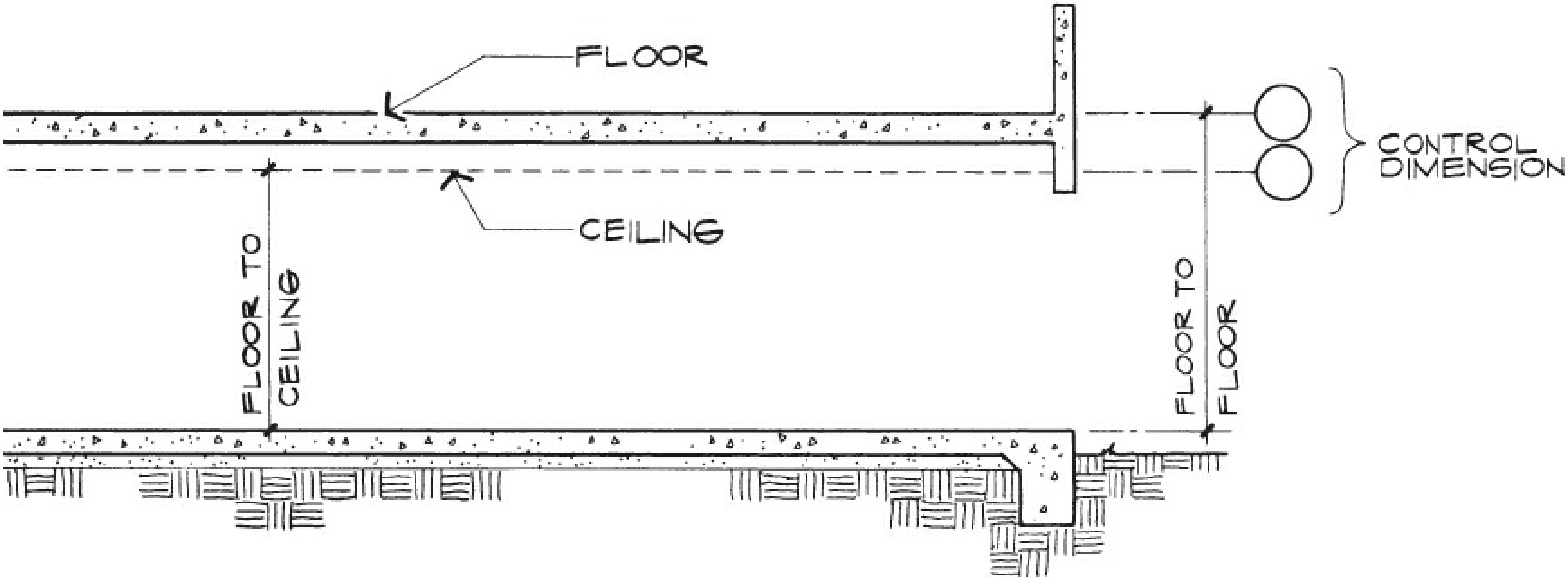


Figure 2.47 Column location in a neutral zone.



[Figure 2.48](#) Neutral zone in a vertical dimension.





[Figure 2.49](#) Vertical control dimension.

FREEHAND AND HAND DRAFTING

Introduction

The idea of drawing is not only developing your eye…hand coordination, but rather gives the designer the ability to break away from mechanical devices and allows the architectural designer to work/design in any context. Let us say, for example, that you were meeting your client at the local coffee shop or restaurant and you had an important idea that you wanted to share with your client. You might use the paper napkin that is available and sketch the idea with your client. This would allow you to draw upside down, so your client might better understand the concept, as he is sitting across from you and it allows you to firmly increase the trust that the client will have in you to translate his/her dream.

Sketching. **Sketching** is the process of developing eye…hand coordination that aids in the design process. The designer can accurately maintain the proportions that are so essential in design.

Initially, all elements are sketched, from the design of a structure to a specific architectural detail. This is a way of conveying to the CAD drafter the ideas you are trying to deliver to the contractors in the field. Details, in particular, must be resolved before the plans, elevations, and building sections are drafted, as they will dictate the shape and

configuration of structural components. The decor around a window, the form of a guardrail, and the connection of a column to a roof are but a few instances exemplifying the control that can be exercised in the freehand detailing process.

Any new idea for assembly should be sketched (freehand) and studied before it is hard… lined manually or drafted on the computer. These detail sketches **(design sketches)** are then sent to the drafter to draw formally. This ability to sketch and communicate puts the employee at a management/supervision level, not at the design level. When we refer to freehand detail, scale is still used, especially at critical intersections.

Drafting. Manual drafting also develops many positive attributes and skills that are needed to sustain employees in the future. These come in the form of:

A. *Patience*. Drafting manually produces a high degree of understanding of one's own limits and timing.

B. *Appreciation for CAD*. Drafting manually allows the CAD drafter to appreciate the increased productivity CAD affords.

C. *Flexibility*. CAD drafters possessing manual drafting skills are more flexible in their ability to create drawings. Suppose, for example, after plotting a plan, that one notices a couple of small errors on a drawing. The errors can be quickly corrected manually to meet a deadline or an appointment.

D. *Presentational drawings*. Many CAD drafters are not proficient in the use of standard drafting equipment. Thus, they are not effective in formatting and producing presentation boards and cutting mats.

E. *Model construction*. Construction of actual mock…up design models, massing models, or presentational scale models are frequently constructed manually for a client's review.

Kinds of Drafting Equipment

Basic Equipment. The drafting tools needed by a beginning draftsperson and the basic uses of those tools are shown in Figure 2.50 and are as follows:

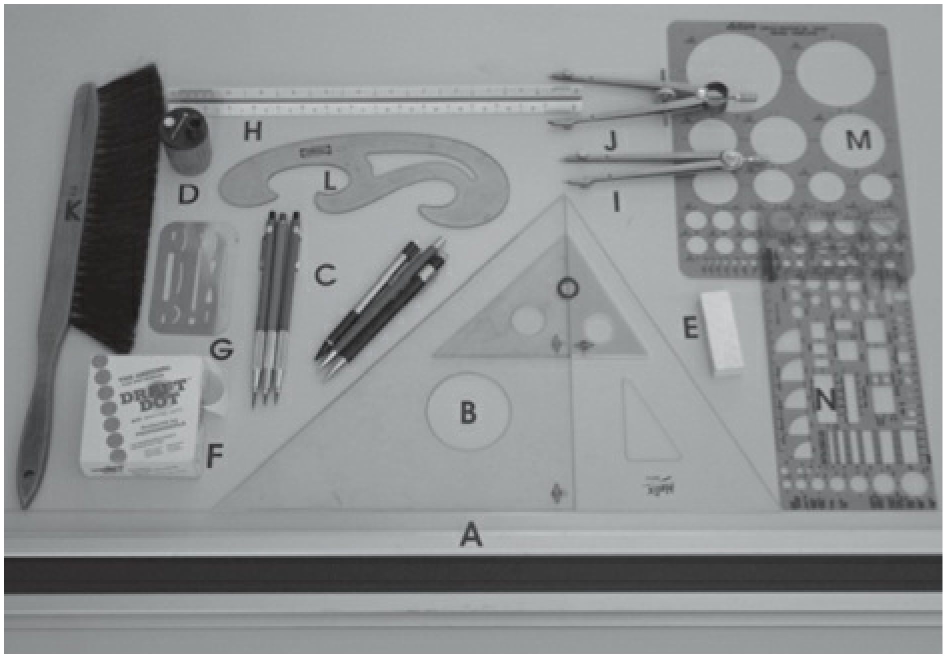


Figure 2.50 Basic drafting equipment.

A. **Circle template.** A prepunched sheet of plastic punched in various sizes, for use as a pattern for circles without using a compass.

B. **Compass.** A V…shaped device for drafting arcs and circles.

C. **Divider.** A device resembling a compass, used mainly for transferring measurements from one location to another.

D. **Drafting dots.** Circular…shaped tape.

E. **Drafting pencil and lead holders.** Housing for drafting leads.

F. **Drafting tape.** Tape used to hold paper while drafting.

G. **Dusting brush.** A brush used to keep drafting surfaces clean and free of debris.

H. **Eraser.** A rubber or synthetic material used to erase errors and correct drawings.

I. **Erasing shield.** A metal or plastic card with prepunched slots and holes used to protect some portions of a drawing while erasing others.

J. **French curve.** A pattern used to draft irregular arcs.

K. **Lead pointer.** A device used to sharpen the lead in a lead holder.

L. **Parallel bar.** A straightedge used to draft horizontal lines and base for the use of triangles. Runs on a wire cable at the sides of the bar.

M. **Plan template.** Prepunched patterns for shapes commonly found in architectural plans.

N. **Scale.** A measuring device calibrated in a variety of units for ease of translating large objects into a small proportional drawing.

O. **Triangle.** A three…sided guide used in conjunction with a parallel bar to draft vertical lines and angular lines. The 30°/60° and 45° triangles are basic equipment.

P. **Triangle, small.** A three‐sided guide used to draft vertical lines when lettering.

Additional Drawing and Designing Equipment. In addition to the tools previously listed, a number of others aid in and simplify the drafting process. They are shown in Figure 2.51.

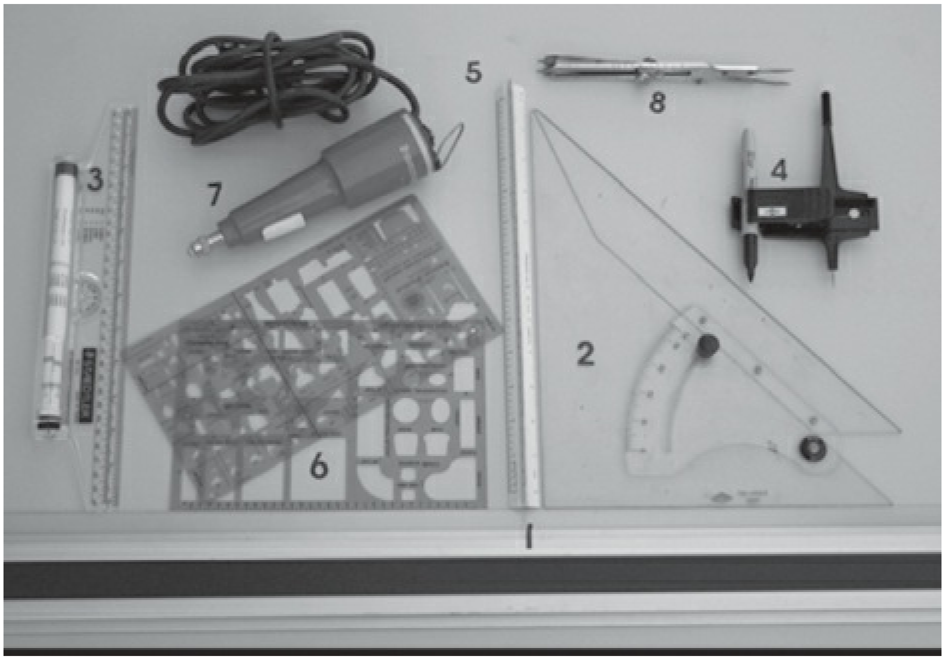


Figure 2.51 Additional drafting equipment.

1. **Parallel bar.** Straightedge.
2. **Adjustable triangle.** A triangle used to draft odd angles such as those found in the pitch (slope) of a roof.
3. **Rolling ruler.** Draws horizontal, angular, and vertical lines, has a protractor function, and can be used as a compass.
4. **Clip compass.** Can be used to hold cutting knives, pencils, inking devices, paintbrushes, felt pens, and the like. Has a 9″ diameter capacity.
5. **Metric rule.** Scale for international work.
6. **Specialty templates.** Include furniture, trees, electrical and mechanical equipment, geometric shapes, and standard symbols. Enables the drafter to show, for example, plumbing fixtures in elevation.
7. **Electric eraser.** Particularly useful when one is working with erasable sepias or ink. Models available include hard‐wired, battery‐operated, and portable (with power charger).
8. **Proportional dividers.** Used to enlarge or reduce a drawing to any proportion. Many have golden mean proportions.

Figure 2.52 shows the correct way of using a straightedge. The lead holder is being rotated as a horizontal line is drawn.

Figure 2.52 Parallel straightedge.

This list is by no means complete. Your selection of tools will be dictated by office standards and the requirements of particular projects.

Using Triangles. Triangles are generally used in conjunction with a straightedge such as a parallel bar, a T…square, or even another triangle (see Figure 2.53). A combination of triangles can produce 15° and 75° lines in addition to a perpendicular 90° angle, a 45° line, and 30° and 60° lines.

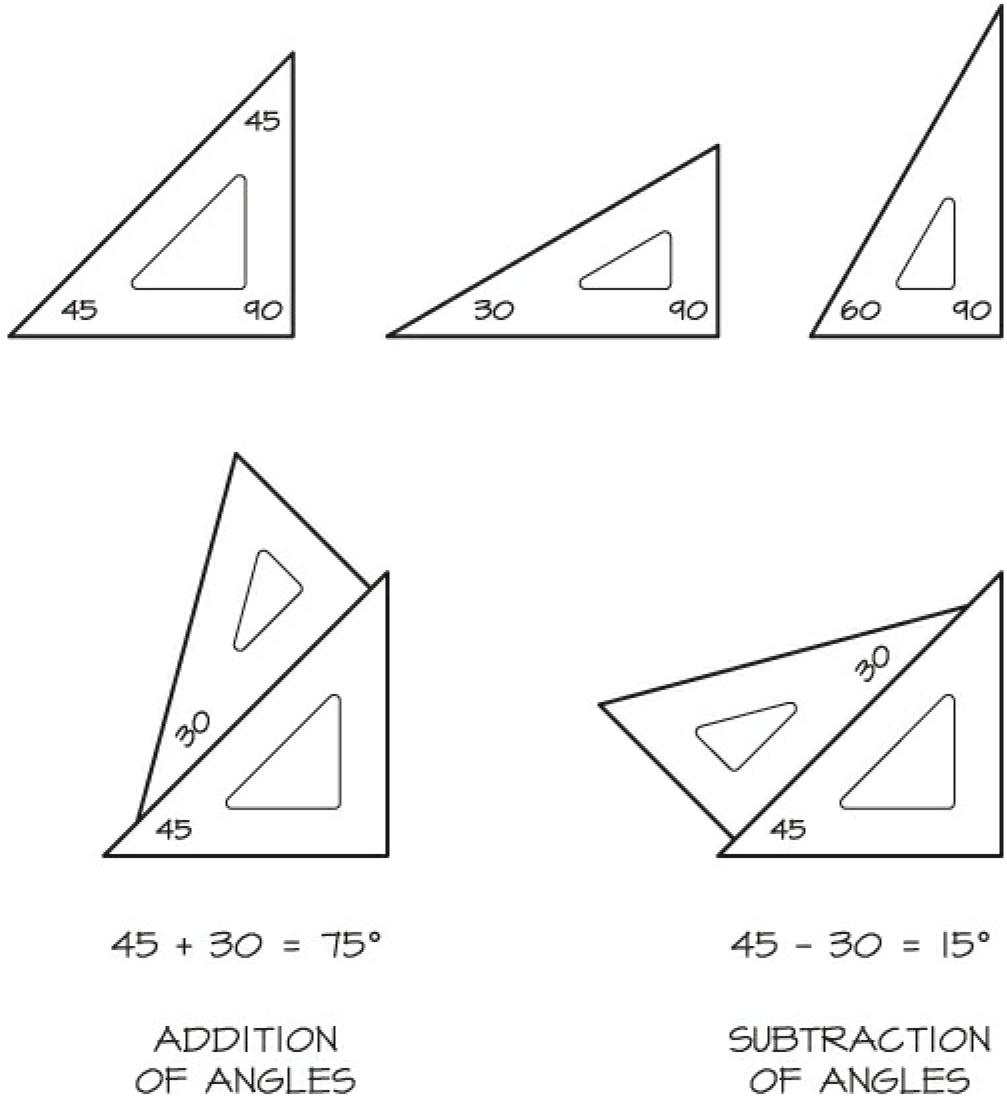


Figure 2.53 Triangles and combinations of triangles.

Using Erasing Shields and Erasers to Draw Dotted Lines. Dotted lines, which are usually called **hidden lines** in drafting, can be drawn rapidly by using an erasing shield and an eraser. An electric eraser is more effective than a regular eraser.

First, draw the line as if it were a solid line, using the correct pressure to produce the desired darkness. Second, lay the erasing shield over the line so that the row of uniformly drilled holes on the shield aligns with the solid line. Next, erase through the small holes. The results will be a uniform and rapidly produced hidden (dotted) line.

This technique is particularly effective for foundation plans, which use many hidden lines. There are, however, some questions inherent in drawing hidden lines. If one hidden line overlaps another, is one deeper (as on a foundation plan), or are they both at the same depth? If a corner has two hidden lines that do not meet, does this mean one is lower than the other? Any mechanical drafting book will explain.

Using the Scale. The most convenient scale to purchase is a triangular scale, because it gives the greatest variety in a single instrument. There are usually eleven scales on a triangle scale, one of which is an ordinary 12″ ruler.

Reading the Scale. Although we call this instrument a *scale,* there is one portion that is a ruler. If you look at a triangular scale (see Figure 2.54A), you will see a side marked 16 on the edge. It measures 12 inches using 1⁄16″ increments. If you can read this, you can read the rest of the information printed on the tool.

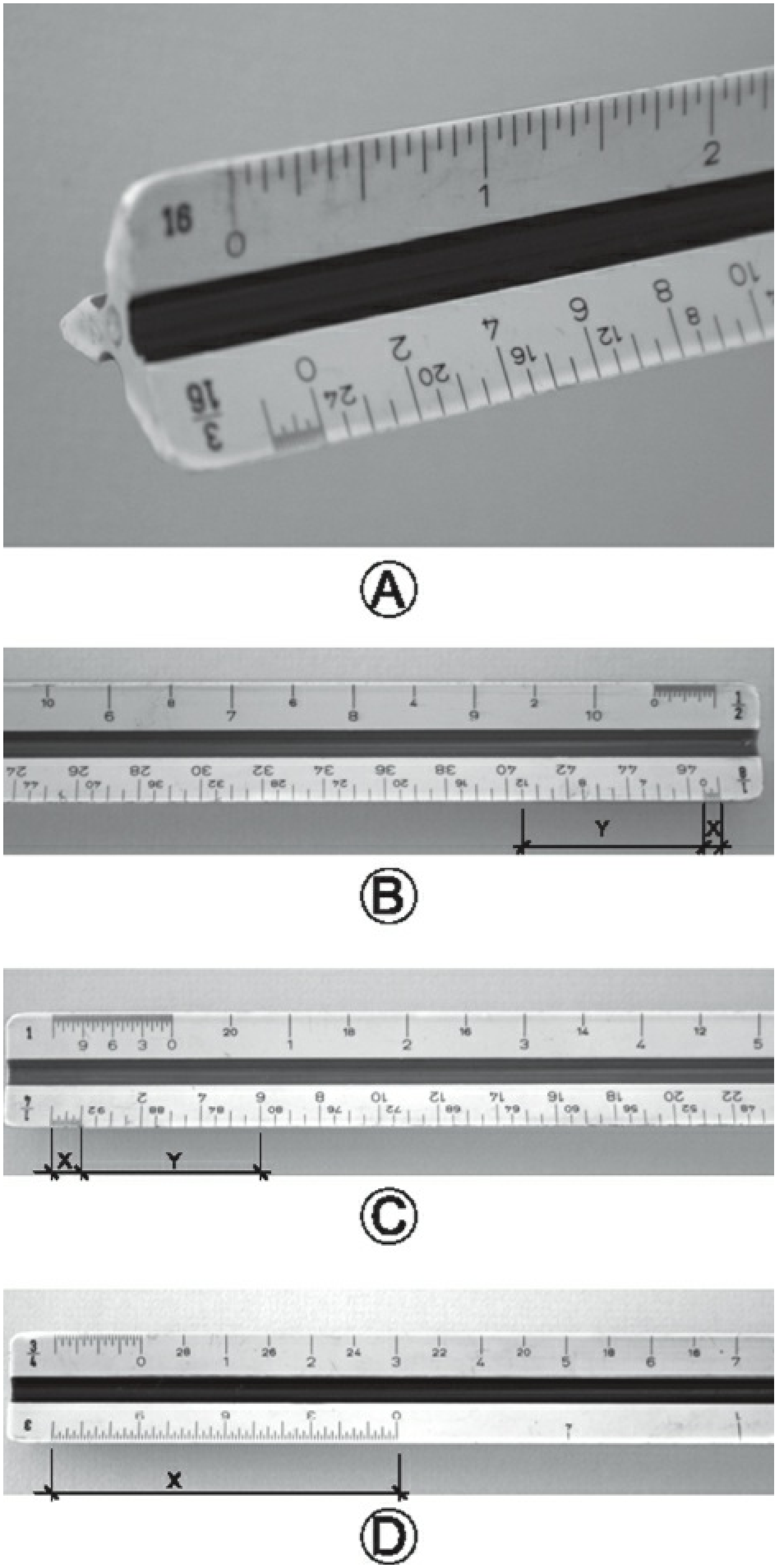


Figure 2.54 Reading a scale.

Let us say you were assigned to do a drawing at ⅛″ = 1′‥0″. This means that 12 inches is

now equal to ⅛ inch. So let us look at Figure 2.54B. One…eighth of an inch has been printed as a 12″ ruler as shown by "X." The area next to this 12″ ruler ("X") has large numbers on it starting with "0" and small numbers in between. We must stay with the small numbers. Note that from "0" to the 12 has been marked as "Y." If you wanted 12′…6″, you would first measure the "Y" and then add the 6″ or half of the "X" area.

The large numbers previously mentioned belong to the 1⁄4" scale, shown in Figure 2.54C. In this instance, the "Y" area measures 6′…0″ and additional inches can be added from the 12″ scale marked "X."

The most difficult scale to comprehend is the 3″ scale. It is not listed as a fraction, as this might confuse you in the beginning (see Figure 2.54D). The "X" on this figure shows the length corresponding to 12 inches; just like a 12″ ruler. A 3″ scale is also called 1⁄4" (quarter) scale, not to be mistaken for a 1⁄4″ scale. Other scales are:

3⁄32″ on one end and 3⁄16″ on the other

1½″ on one end and 3″ on the other

3⁄4″ on one end and 3⁄8″ on the other

Confusion is often caused by the numbers between the two scales. Look carefully at these numbers and notice two sets. One set is closer to the groove that runs the length of the scale and the other is closer to the outside edge. The numbers near the edge will be the feet increments for the smaller scale, and the other numbers will be the feet increments for the larger scale.

It is easy to make an error by reading the wrong number, because the "32" on the ⅛″ scale is so close to the "32" on the 1⁄4″ scale. Similar pitfalls occur in other pairs of scales on the triangle scale.

Most engineering scales use the same principles as architectural scales, except that measurements are divided into tenths, twentieths, and so on, rather than halves, quarters, and eighths. The section on metrics explains these metric scales further.

Using Drafting Tape. A simple but effective method of taping original drawings is to keep the edges of the tape parallel with the edges of the **vellum** (a translucent, high…quality tracing paper), as shown in Figure 2.55. This prevents the straightedge from catching the corner of the tape and rolling it off. Vellum taped at an angle creates unnecessary frustration for the beginning draftsperson. Drafting supply stores sell tape in a round shape (dot), which is even better.

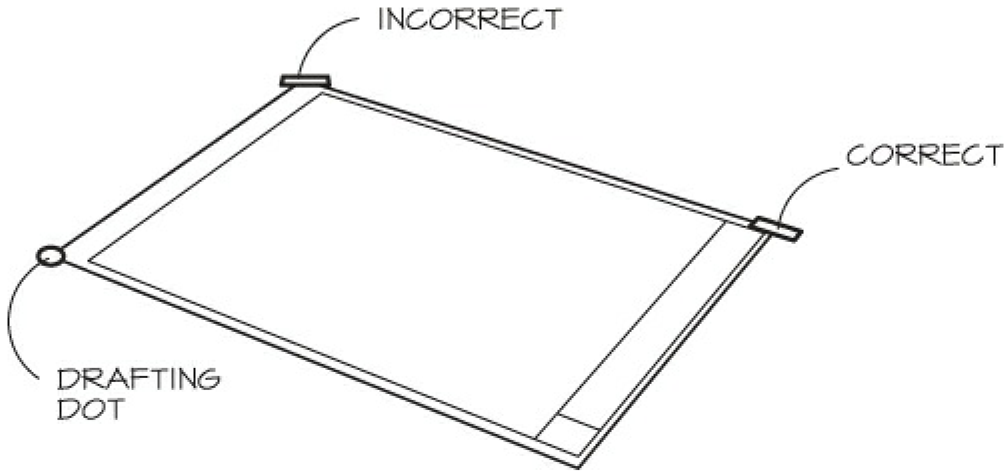


Figure 2.55 Correct placement of drafting tape.

Rolling Original Drawings. Most beginners begin rolling drawings in the wrong direction. In their attempt to protect the drawings, they often roll the print or the original so that the printed side is on the *inside,* as shown in Figure 2.56B. However, the correct way is to roll the sheet so that the artwork is on the *outside,* as shown in Figure 2.56A.

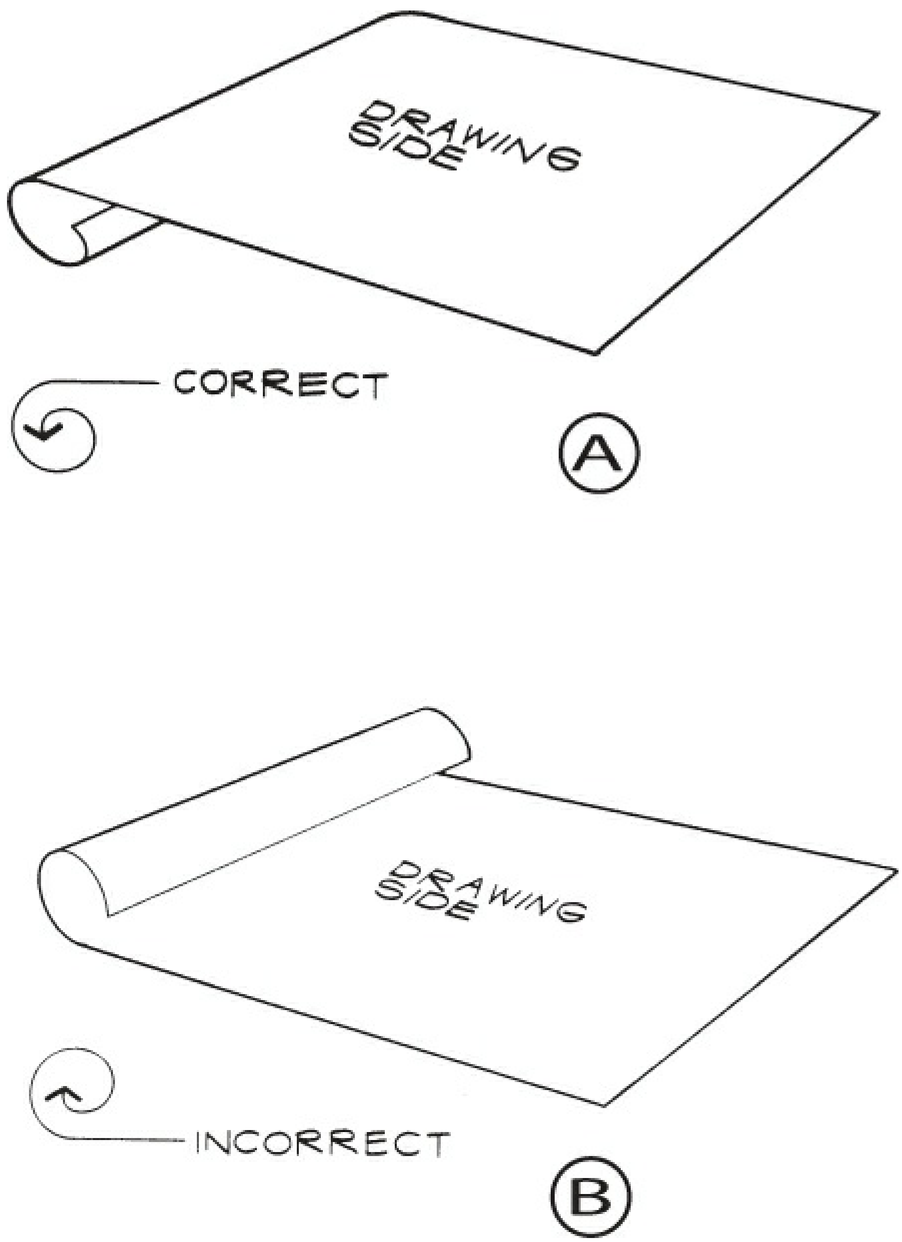


Figure 2.56 A. Correct way to roll a drawing. B. Incorrect way to roll a drawing.

When a set of prints is unrolled and read, the drawings should roll toward the table and should not interfere with easy reading by curling up. If originals are rolled correctly, the vellum curls toward the drafting table, preventing it from being torn when drafting equipment slides across it or when it is being reproduced.

Selecting and Using Drafting Pencils

Types of Leads. Seventeen grades of leads are available, but only a few of these are appropriate for drafting. Harder leads are given an "H" designation, whereas softer leads are given a designation of "B." Between the "H" and "B" range are "HB" and "F" leads. The softest "B" lead is 6B (number 6); the hardest "H" lead is 9H (number 9). See Figure 2.57.

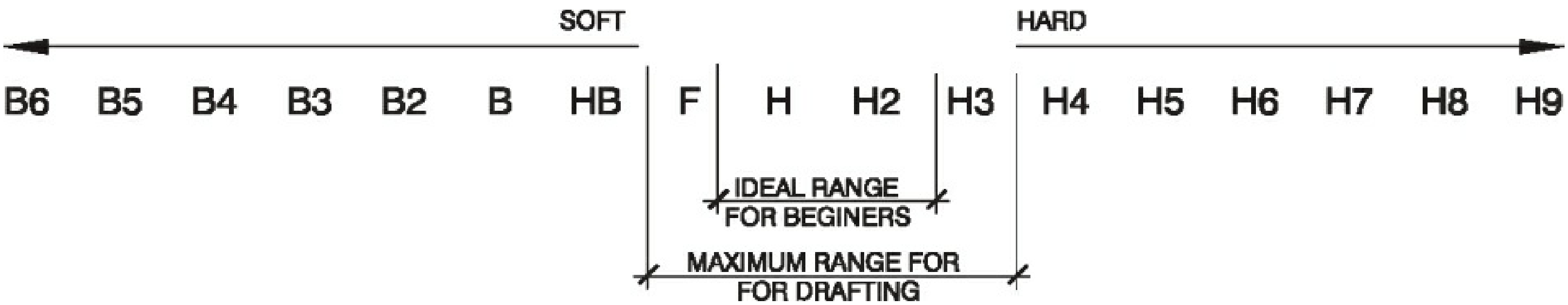


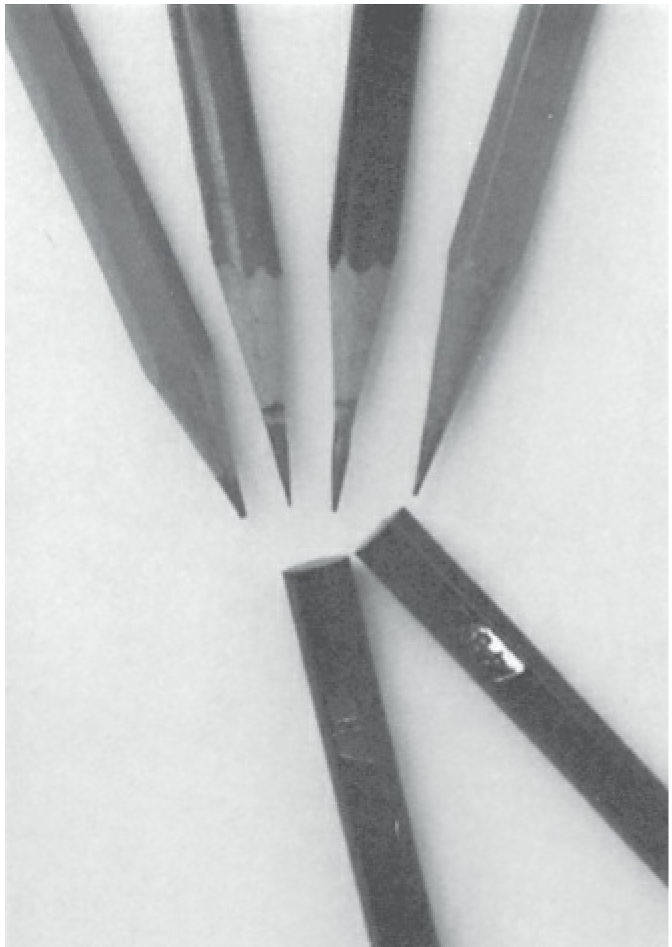
Figure 2.57 Lead hardnesses.

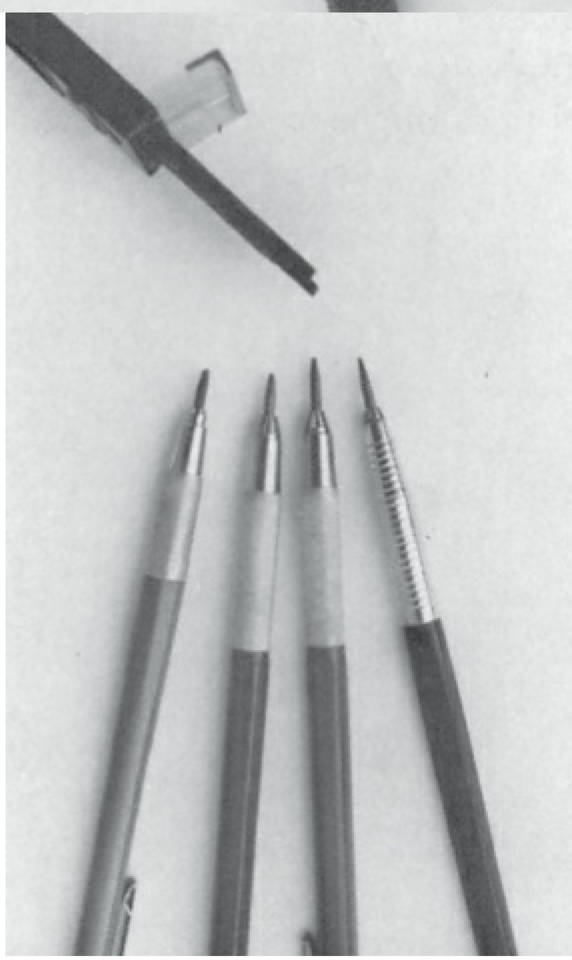
Selection Factors. Only the central range of leads is used for drafting. 2H, 3H, and 4H are good for drafting, while H is good for a medium and dark object lines.

However, many other factors also determine the choice of pencil. Temperature and humidity may dictate that certain leads be used. Manufacturers' designations of the particular grades vary. Also, the natural pressure that the drafter places on the pencil varies from individual to individual. The reproduction method to be used also determines the choice of lead grade.

For reproduction, a crisp line is better than a dark one because a dark, broad line may end up as a blur on the final image. The old diazo prints are still being used today but are rapidly being replaced by copiers. Diazo prints (blue or black lines on a white background) have to block out light, so a dense line is more important when using this reproduction system.

Pencils versus Lead Holders. Wood pencils are fine, but serious drafting requires mechanical lead holders. See Figure 2.58. Wood pencils require sharpening of both the wood and the lead, which is time consuming. More important, a lead holder allows you the full use of the lead, whereas a wood pencil does not.





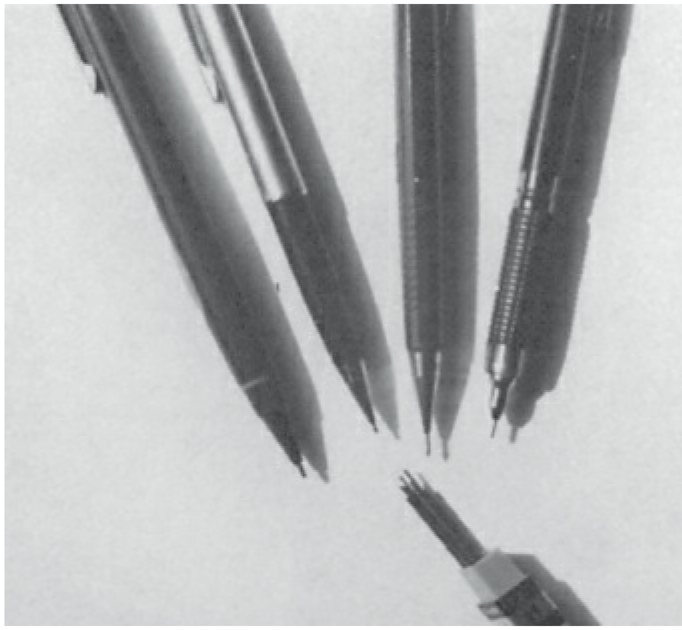


Figure 2.58 Types of lead holders and pencils.

Lead Pointers. A **lead pointer**, a tool used to sharpen drafting leads, is a must. Sandpaper can be used for both wood pencils and lead holders, but it is not nearly as convenient, consistent, or rapid as a lead pointer. A good practice after using a lead pointer is as follows: Take the sharpened lead and hold the pointer perpendicular to a hard surface such as a triangle; crush the tip of the lead slightly; then hone the tip by drawing a series of circular lines on a piece of scratch paper. This stops the lead from breaking on the first stroke. Roll the pencil as you draw to keep a consistent tip on the lead. Draw either clockwise or counterclockwise, depending on whichever produces the best line and is the most comfortable for you. Note the position of your fingers and thumb at the beginning and end of the line.

Computer Drafting. **Computer_aided drafting** (CAD) has significantly affected the field of architecture. This section does not instruct you on how to use the computer or the various CAD programs (there are books solely devoted to CAD that do), but rather teaches you how CAD programs can best be used to become an effective tool in an architectural office.

What the Drafter Will Learn

CAD does *not* refer to what the computer allows you to do; rather, it refers to the process of taking the conventions, symbols, and the drawing dimensions and incorporating them into the computer to be adjusted for the task at hand. Literally, we are talking about design that uses the computer as just another tool, albeit a very powerful and convenient one. In this section, we discuss:

A. Office setup and expectations.

B. CAD standards used in the industry, such as line weights, color, and layering.

C. Effective use of 2…D and 3…D spaces. These discussions will help the beginner to

become a more effective user of paper space (two…dimensional layout space) and model space (three…dimensional modeling space).

D. Scaling drawings and lettering.

E. Three…dimensional drafting.

F. Effective cartooning.

G. Using vectors in the drawing process.

H. The near future of computers in our industry.

The computer, in the architectural industry, is becoming increasingly important. Just as with other tools, the CAD drafter must learn to use the computer through specific instruction. After the drafter has mastered the techniques, the computer can aid significantly in the creative process. However, in this process, the drafter is controlling the tool, rather than the computer controlling or constraining the drafter. Similarly, the CAD drafter concentrates on translating the intent of the designer into a workable set of construction documents, with the computer as one of his or her creative tools.

Each computer drafter should be well trained so that he or she can prepare a set of construction documents from scratch. Training will allow you, the CAD operator, to integrate your understanding of the system with your knowledge of architectural drawings and standards and become immediately effective in production.

OFFICE STANDARDS

Offices have a set of standards that employees must follow. This is essential in the industry, not only because many drafters may be working on the same project, but also to ensure uniformity of the language that the drafters speak. Adhering to standards helps coordinate drawings for a firm's associates both inside and outside the office.

Standards establish sheet size, scales used, standard line and symbol conventions, placement and positions of drawings, and sheet modules, to mention a few items. These standards are often kept on the drafter's desk and are referred to as the **drafting room manual,** the **office procedure manual,** or something similar. Computers are no different. They too have their standards, and although standards may differ slightly from job to job or office to office, they should be rigidly followed. Standards do change, and making or suggesting a revision adds to both their usage and their ability to become viable office solutions.

Although standards are established by individual offices and are often based on existing drafting room manuals, the introduction of computers to the arsenal of production tools has created a need for national and international standards. Associations such as the American Institute of Architects, National Institute of Building Sciences, Construction Specifications Institute, and even the military, to mention just a few, have in fact produced national CAD standards.

When using standards, a drafter should not be so dependent on existing standard templates that he or she is unable to develop new ones if the job calls for them. Flexibility and creativity are important. You may find two types of computer drafters in an office. One drafter can develop new office standards as the need requires. This type of drafter is knowledgeable and flexible and knows how to set up line types, lettering size, sheet size, and scales. A second type is the “running scared” CAD employee, who copies office standards from various offices and uses a large number of CDs or flash drives with predrafted, predetermined templates of sheet sizes, lettering, sizing, and so on. Office managers will evaluate individual performance and conformance to standards, and if you do not keep up with the state of the technology or fail to recognize the needs of the office, your job may be jeopardized.

To help drafters avoid this dilemma, the following pages describe the needs of the architectural office and why certain standards are enforced, how to develop them, and how to understand them.

In this section, we discuss the following topics with regard to standards and CAD use:

1. A profound change in perception
2. Importance of standards in the electronic world
3. Vector versus raster
4. X…referencing (XREF)
5. Oddly scaled drawings and computer manipulation of existing drawings
6. Paper
7. Paper space/virtual space (model space)
8. Scaling factor
9. Layering
10. Updating old drawings
11. Pen setting/line weights/color
12. Lettering size
13. Procedure for the preparation of construction documents
14. Disadvantages
15. Advantages
16. The future of CAD

A Profound Change. The most profound change caused by the advent of computer…aided and computer…assisted drafting is the manner in which we perceive and execute drawings. The first of these changes in perception is the way in which we view structures. With the use of CAD, structures should be drawn at full scale. This is made possible

because we are working in virtual space (model space), which is unlimited.

When designing and drawing in full scale on the computer, you can look around the space you are occupying and draw relationships based on real…world sizes. The monitor becomes a window through which you are viewing this full…size structure. The printer/plotter becomes a photograph of this image displayed on the monitor screen (see Figure 2.59).

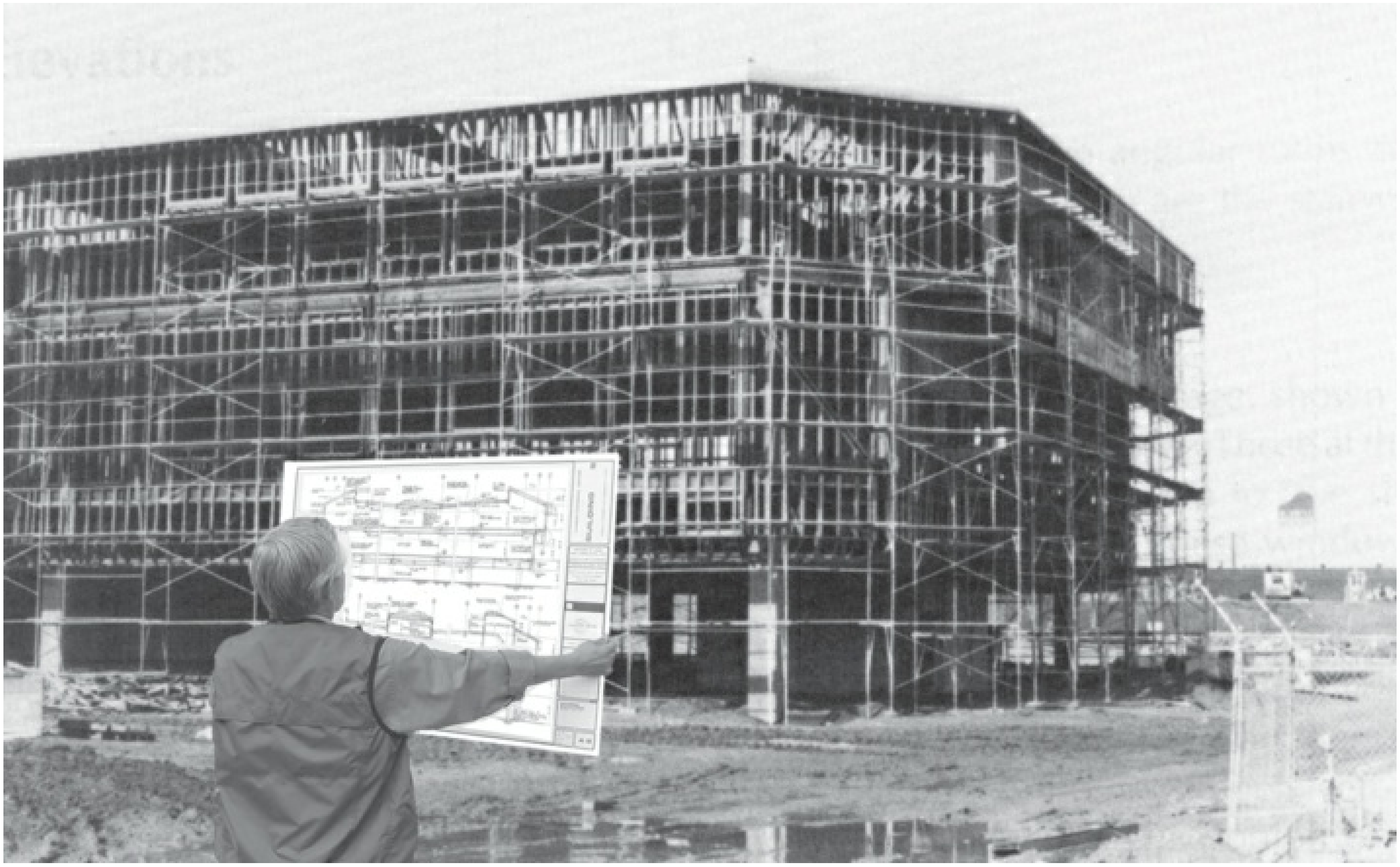


Figure 2.59 Drawing and monitor become one and the same relative to perception.

Standardization in the Electronic World. Standardization in the electronic world is very important because our whole industry is based on communicating ideas. We can do this only if each of the participants—architects, drafters, associates (mechanical, structural, electrical engineers), and so forth—speak the same language.

If a set of drawings has been done in layers, as is often the case, the titles of these layers become critical for identification. To aid in identification, a CAD drafter must use the standards (standard titles) to which the office subscribes and plot them out onto a chart similar to that found in Figure 2.60.

FILE

DRAWING

LEGEND

A — ARCHITECTURAL
M — MECHANICAL
P — PLUMBING
S — STRUCTURAL
E — ELECTRICAL

LAYER	NAME																		
A.																			
A.																			
A.																			
A.																			
A.																			
A.																			
A.																			
A.																			
A.																			
A.																			
A.																			
A.																			
A.																			
S.																			
S.																			
S.																			
S.																			
S.																			
S.																			
E.																			
E.																			
E.																			
E.																			
E.																			

Figure 2.60 Sample layout for layers.

Generally speaking, drawings are categorized by subject—for example, architectural, mechanical, structural, and the like. In manual drawings, “A” is for architectural, “S” is for structural, and so on. Look at Figure 2.61 for such a breakdown. Notice the 13 “A” drawings listed in the left column. The walls of the floor plan are drawn on one layer and given the name A…WALL. All of the appliances (such as plumbing) are drawn on another layer called A…FLOR, windows and doors on A…GLAZ and A…DOOR, dimensions on A…ANNO…DIMS, and so on. To produce a drawing for construction, we must print A…WALL, A…FLOR, A…GLAZ/DOOR, and A…ANNO, along with a host of other layers, all of which contain reference bubbles and titles. To print a furniture plan for the client, you would most certainly need layers A…WALL, A…FURN, and A…ANNO.

LEGEND

A — ARCHITECTURAL
M — MECHANICAL
P — PLUMBING
S — STRUCTURAL
E — ELECTRICAL

LAYER	NAME	A-1.0 SITE PLAN	A-2.0 FLOOR PLAN	A-2.1 CEILING PLAN	A-2.2 FURNITURE PLAN	A-2.3 FINISH PLAN	A-3.0 ELEVATIONS	A-4.0 SECTIONS	A-5.0 SCHEDULES	A-6.0 INT. ELEVATIONS		S-1.0 FOUNDATION	S-2.0 FLOOR FRAMING	S-3.0 ROOF FRAMING	S-4.0 WALL SECTION		E-1.0 POWER PLAN	E-2.0 LIGHTING PLAN	E-3.0 REFLECTED C.P.
FILE		2000_A-1.0	2000_A-2.0				2000_A-3.0	2000_A-4.0	2000_A-5.0	2000_A-6.0		2000_S-1.0	2000_S-2.0	2000_S-3.0	2000_S-4.0		2000_E-1.0	2000_E-2.0	2000_E-3.0
A. SITE	A-SITE	●																	
A. WALL	A-WALL		●	○	○	○							○	○			○	○	○
A. FIXTURES	A-FLOR		●		○	○													
A. DOORS	A-DOOR		●		○	○												○	
A. WINDOWS	A-GLAZ		●		○	○												○	
A. DIMENSIONS	A-ANNO-DIMS		●			○							○	○					
A. CEILING PLAN	A-CEIL			●															●
A. FURNITURE	A-FURN				●														
A. NOTES	A-ANNO					●													
A. BORDER & TITLE	A-TBLK		●	●	●	●	●	●	●			●	●	●	●		●	●	●
A. EXTERIOR ELEVATION	A-ELEV-EXTR						●								○				
A. INTERIOR ELEVATION	A-ELEV-INTR							●											
A. BUILDING SECTION	A-SECT								●										
S. NOTES	S-ANNO											●							
S. DIMENSIONS	S-DIMS											●							
S. FOUNDATION WALLS	S-WALL											●							
S. FOOTING CONVENTIONS	S-FNDN											●							
S. FRAMING MEM. FLOOR	S-FRAM-FLOR												●						
S. FRAMING MEM. ROOF	S-FRAM-ROOF													●					
E. NOTES	E-ANNO																●		
E. EQUIPMENT	E-EQUP																●		
E. WALL FIXTURES	E-FIXT-WALL																	●	
E. CEILING FIXTURES	E-FIXT-CEIL																		●
E. SUSPENDED CEILING	E-CEIL																		●

Figure 2.61 Example of layers and their titles.

Let us say you sent the engineer the floor plan described earlier: A‐WALL, A‐FLOR, A‐DOOR, A‐GLAZ, A‐ANNO‐DIMS, reference bubbles, notes, titles, and so forth. The engineer has to know how to load the layers needed for an S drawing. If the structural engineer is producing a roof framing plan or a ceiling joist plan, he or she will initially need not only the wall layer, but also the dimension layer. The dimension layer can be eliminated on the final printing. In this way, the wall (A‐WALL) layer is used as a base for a multitude of other drawings. A quick look at Figure 2.61 reveals that the A‐WALL layer is used for the floor plan, ceiling plan, furniture plan, and finish plan, as well as the floor framing plan, roof framing plan, and, on the simplified chart, the power plan, lighting plan, and the reflected ceiling plan. This is called cross‐referencing, or X‐referencing.

Vector versus Raster. It is imperative that all CAD drafters know the difference between vector drawings and raster drawings because of the ways in which each file format can be used. Both raster and vector images can be manipulated. **Raster** images are made up of pixels; a photo manipulation program must be used with a raster image. You can remove items from the image and elongate, stretch, or compress the image. You can even change the position of the image relative to the paper and format for presentation. However, you cannot easily change the geometry.

Vector drawings are done both two‐dimensionally and three‐dimensionally. Vector drawings are actually lines, planes, and geometric shapes drawn in virtual space. Height, width, and depth are described as X, Y, and Z directions. This means you can rotate a three‐dimensional form and look at it from any of the six principal directions—front, back, left, right, top, and bottom (or underside)—and an unlimited number of views in between.

For importing a digital drawing from a vendor, you should request a vector drawing. Figure 2.62 shows a single‐hung window with a transom made of vinyl and imported as a vector file. Such drawings represent the basic manufacturer's configuration, which can be placed with the header, exterior finish, interior finish, and waterproofing methods to produce a construction detail for a specific application.

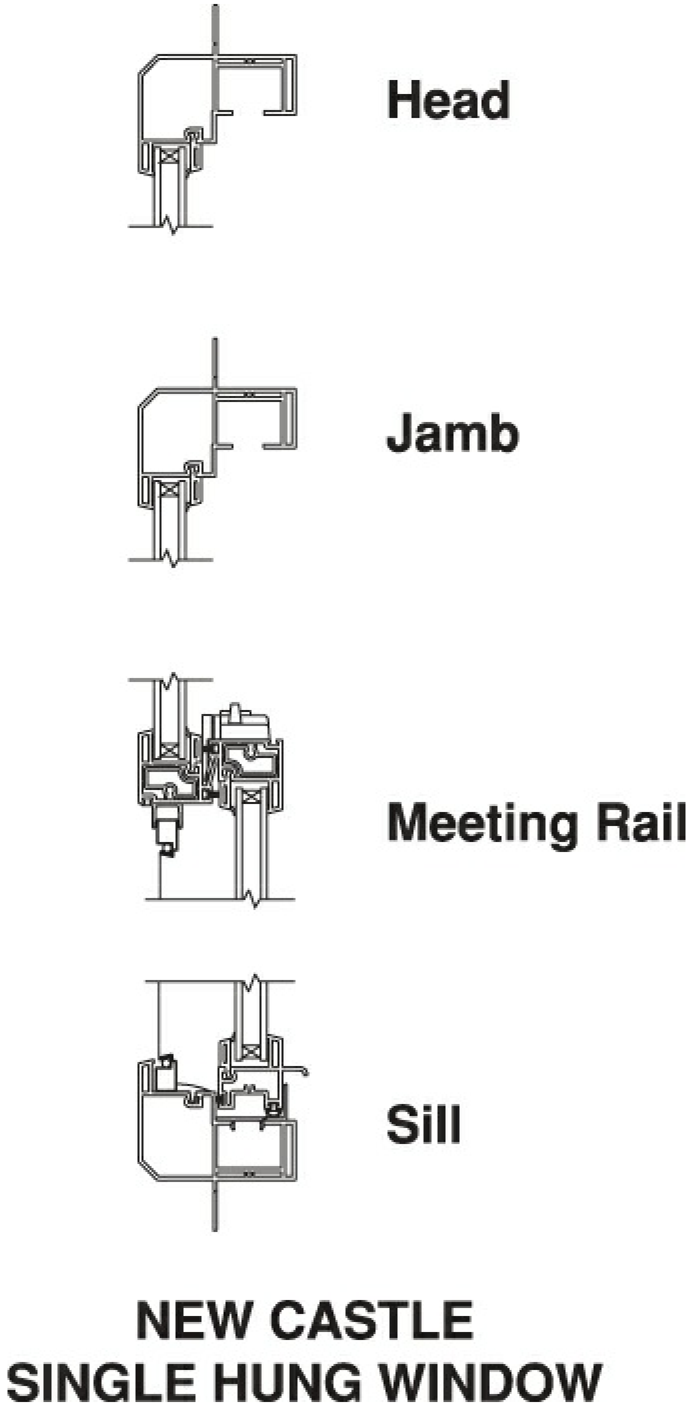


Figure 2.62 Vinyl window configurations.

(Courtesy of Certainteed Windows. Reprinted by permission from *The Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

Figure 2.63 shows a recommended installation detail. The computer drafter can take this detail and adapt it to a specific application while adding pertinent design features. When requesting both basic shapes and installation details, ask for the file format your office typically uses. Usually, that will be DXF or DWG. The majority of CAD programs can easily manipulate these file types.

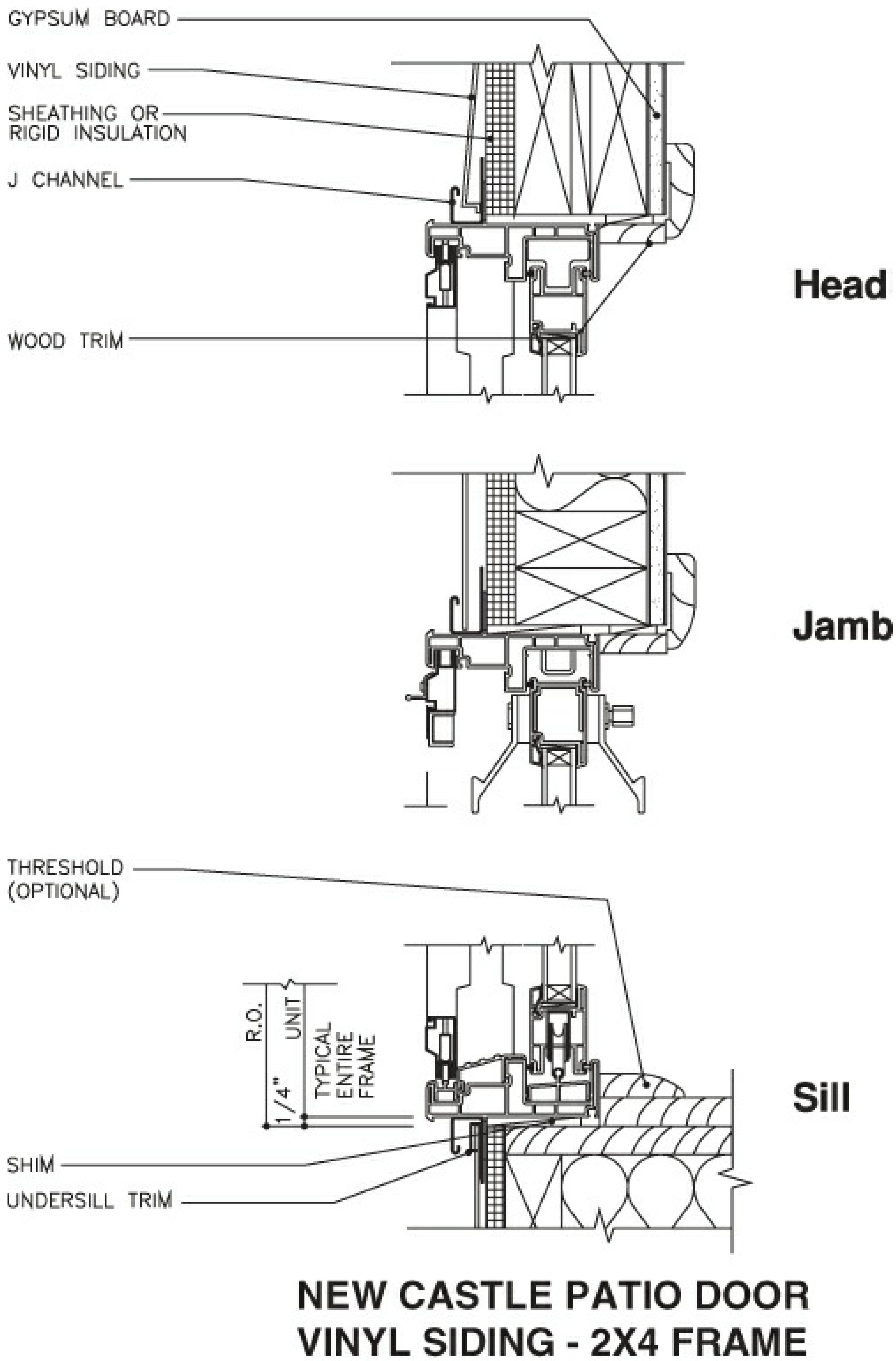


Figure 2.63 Manufacturers' installation details in DWG format.

DWG versus DXF. If a drawing is to be sent or received electronically, it must be formatted. Although there are other formatting methods, DXF and DWG are most typically used.

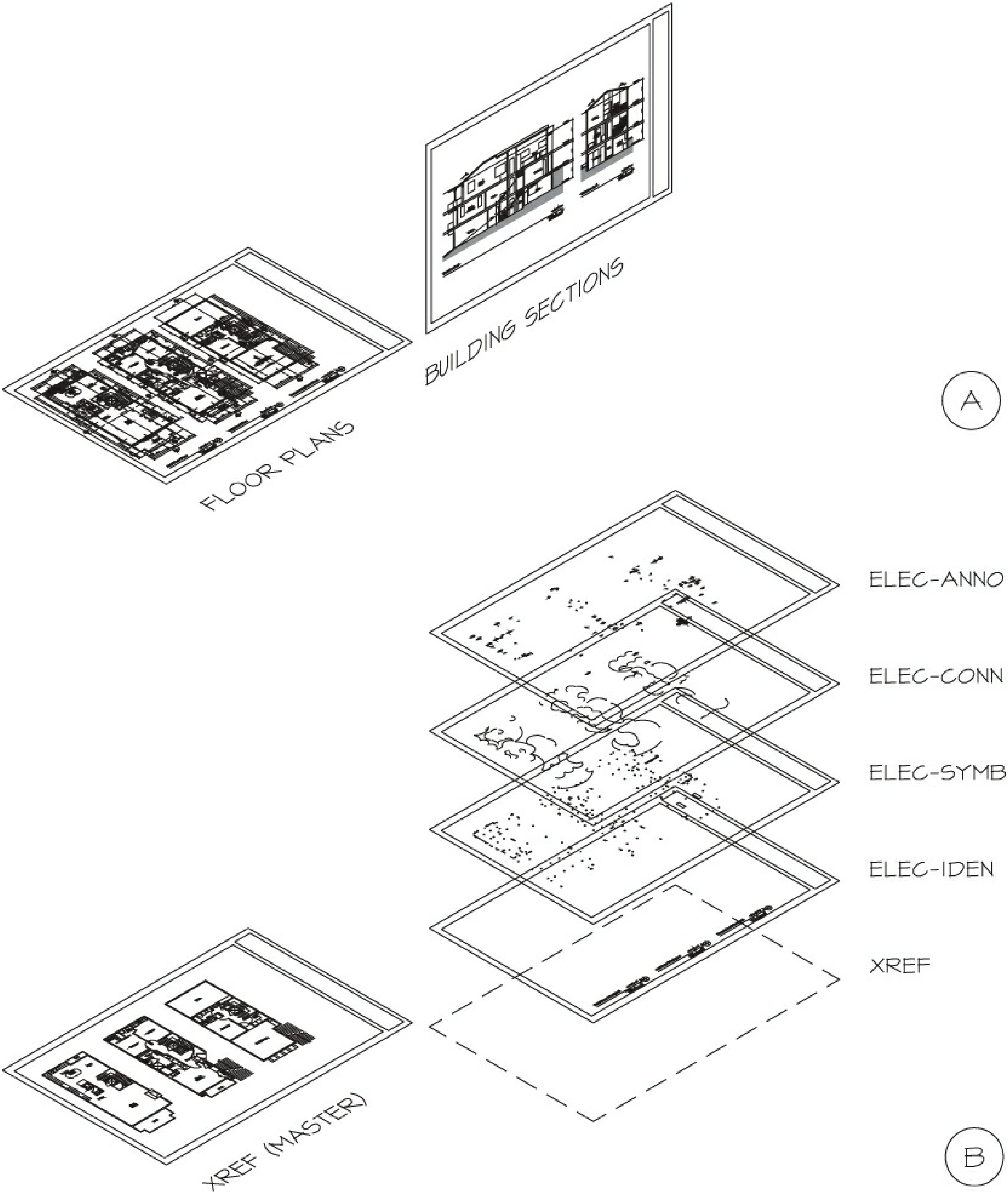
The **DWG** format, which is the most desirable, is the easiest for the AutoCAD drafter to use, change, or correct because it has all the ingredients needed to produce the end result.

The **DXF** (short for *drawing exchange format*) strips down the total drawing sequence in a way that makes it easier to translate. Because it is a stripped…down form, you cannot perform certain tasks; although the final visual image is complete, pertinent information

is missing and thus it cannot be easily manipulated. It saves the final geometry, but many of the steps used to produce the final geometry are missing. DXF is easier to exchange with other programs. Not all programs can use DWG formats easily. If you wish to send a drawing electronically or place a drawing on a web site strictly for viewing, then explore a DWF format.

Various AutoCAD programs cannot open **DWF**…formatted drawings, because this format provides a level of protection useful for maintaining a more secure transmission. Your standards, symbols, layers, sheet setups, and so forth will not be entirely usable by the person to whom you transmit the file in DWF format.

X–Referencing (XREF). Cross–referencing, in the architectural industry, refers to the process of referencing one drawing to another by means of reference bubbles (see Figure 2.64). In the computer industry, the term *X…referencing* (**XREF**) sounds like cross…referencing, but it is not the same. XREF means "externally referenced" drawings. XREF is used to combine drawings and keep the entire set of construction documents updated with the most recent version of a drawing. A secondary datum is now being used to produce drawings. The example shown in Figure 2.64 is an electrical plan. The floor plan (master) becomes the externally referenced drawing and is not directly a part of the electrical plan layers.



[**Figure 2.64**](#) XREF.

Computer‐generated drawings, with their intricate network of finely tuned layers, titles,

and patterns, are produced almost as if they were a family. Base drawings, such as exterior and interior walls showing some of the basic fixtures and stair locations, are often referred to as *masters* or **parent drawings**. Their offshoots, such as framing plans, electrical plans, building sections, and so on, are commonly referred to as *children* or *submasters*. The plot sheets serve the parents and children by presenting specific drawings and information (*maids* or *servants*). A composite of these drawings may include title blocks, notes, and other features always found on every sheet (e.g., title block) or those features found only on specific sheets. Because CAD drawings can be done using multiple files, the process of delegating certain information to certain drawings is called *XREFing* and allows certain drawings to be used in multiple ways.

Figure 2.65 shows a sampling of an XREF standard for a hypothetical office. Figure 2.66 provides examples of a master, submaster, and servant. This cross…referencing has the same meaning in manual drawings as it does in CAD drawings, whereas XREF refers to a special process unique to computer…generated drawings.

Preliminary Documentation of Office XREF Standard

Schematic Design/Design Development (MASTER) Naming: YearMonthProjectNumber-MAST.dwg (YYMM##-MAST.dwg) 000101-MAST.dwg			
	MAST	Master Design Drawing	Walls, Doors, Windows, Stairs, Fireplaces, Room Labels,
			Plumbing Fixtures, Closets (What you need for the Client)

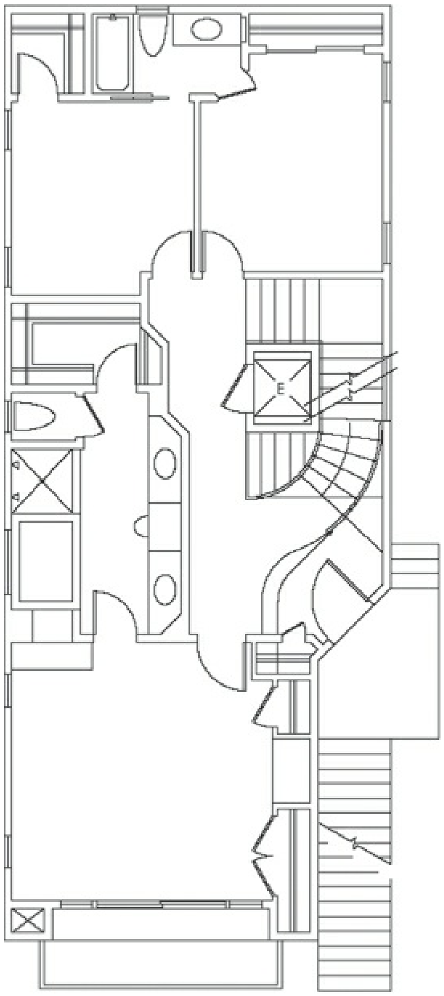
Design Development/Construction Documents (Sub-Masters) Naming: YearMonthProjectNumber-FLOR.dwg (YYMM##-FLOR.dwg) 000101-FLOR.dwg			
XREF	**Listed in order of importance**		**Description**
MAST	**NBHD**	Neighborhood Compatibility	If needed
MAST	**FLOR**	Floor Plans	Poche, Hatching, Notes, Dimensions
MAST	**ROOF**	Roof Plan	
MAST	**ELEV**	Elevations	
MAST	**SECT**	Building Sections	
MAST	**SITE**	Site Plan	Modify TOPO to start Could also include a separate Grading Plan
MAST	**FRAM**	Framing/Foundation	All Structural Drawings
MAST	**ELEC**	Electrical Plans	
MAST	**OTHR**	Other Architecture	If in project program
	TBLK	Titleblock	XREF'd to ALL plotsheets
	TOPO	Survey/Topography	Produced by surveyor

PLOTSHEETS or Layouts w/ modelspaces. It is possible to have all sub-masters drawn on their respective plotsheet modelspaces.			
XREF	**Sheet**	**Sheet Title**	**Description**
	T-1.0	Title Sheet	
	T-1.1	General Notes	
	CF-1R	Title 24/Energy Calcs	
SITE	**A-1.0**	Site Plan	
TOPO	**A-1.1**	Survey/Topography	
NBHD	**A-1.2**	Neighborhood Compatibility	If required for submittal
SITE	**A-1.3**	Grading Plan	If not included in Site Plan
FLOR	**A-2.0**	Floor Plans	
	A-2.1		
ELEV	**A-3.0**	Exterior Elevations	
	A-3.1		
SECT	**A-4.0**	Building Sections	
	A-4.1		
MAST	**A-5.0**	Roof Plan	
INTR	**A-6.0**	Interior Elevations	
	A-6.1		
OTHR	**A-7.0**	Other Architecture	
	A-7.1		
	A-8.0	Schedules	
	A-8.1		
	A-D.1	Architectural Details	
	A-D.2		
FRAM	**S-1.0**	Foundation Plan	
FRAM	**S-1.0B**	Basement Framing Plan	If needed for space reasons
FRAM	**S-1.1**	First Floor Framing	
FRAM	**S-1.2**	Second Floor Framing	
	S-1.3		
FRAM	**S-2.0**	Roof Framing	
	S-2.1		
	S-D.1	Structural Details	
	S-D.2		
ELEC	**E-1.0**	Electrical Plans	
	E-1.1		

Figure 2.65 A sample XREF standard.

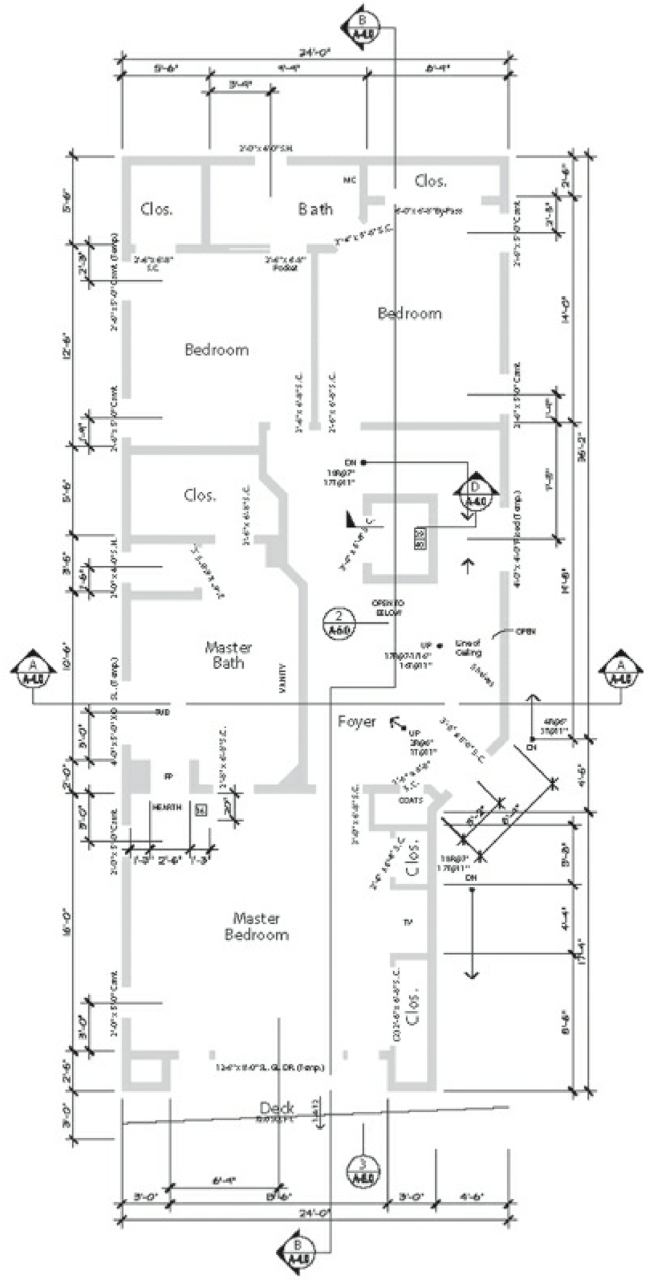
MASTER

(PARENT)



SUBMASTER

(CHILD)



SLAVE

(SERVANT)

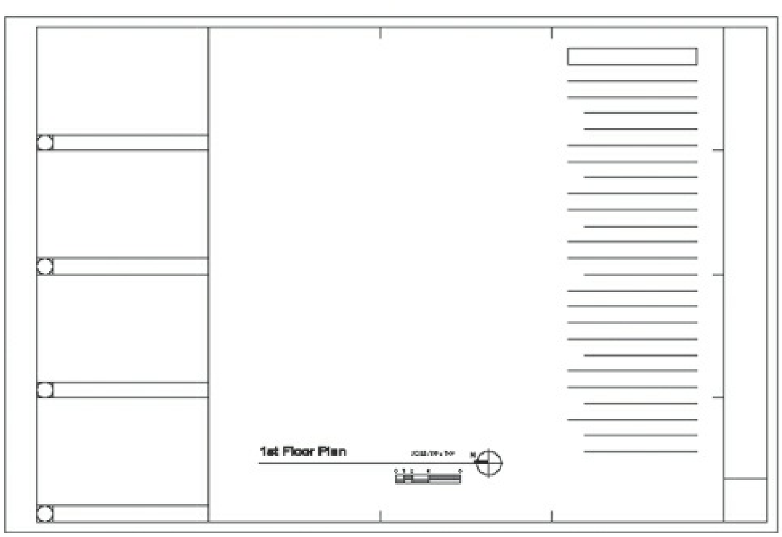


Figure 2.66 A floor plan developed through XREF.

(Courtesy of Norman Lebeau, owner.)

Oddly Scaled Drawings. A peculiar group of computer‐generated drawings that are beginning to find their way into the construction industry are drawings without a specific or known scale. These are drawings that may have been drawn to scale initially, but were resized to fit the paper on which they were plotted. Even worse are drawings and notes that have been reduced so that you need a magnifying glass to read them.

To avoid such a catastrophe, all CAD drafters should be able to cartoon a drawing and adhere to office standards with regard to sizing and heights of lettering.

The reduction process has found its way into the CAD system with a command called “Print to Fit,” which prints the drawing on a sheet of paper regardless of scale. If the CAD drafter anticipates how much the drawing will be reduced, office standards for lettering height can be maintained.

If a floor plan would fit a 24 × 36 piece of paper at 1⁄4″ = 1′‐0″ and the office standard is to maintain tall lettering and 1⁄4″ tall titles, the drafter must produce lettering at 6″ in height (at 1⁄4″ scale) and titles 12″ tall.

Computer Scanning and Reworking of Existing Drawings. Most computers are equipped with scanners and printers. Older drawings (hard copy), diazo prints, vellum originals, and photographs can be scanned into the computer. These drawings can then be altered and changed easily to produce a new master drawing. Once material is “in” the computer, layers (overlays) can be employed to update drawings and produce restoration drawings. Because of the flexibility and speed with which computers operate, they can technically create almost everything that can be done via reprodrafting, composite drafting, paste‐up drafting, scissors drafting, photo drafting, and more.

Paper. Paper comes in various sizes. The standard and nonstandard sizes are listed in Figure 2.67. Nonstandard‐sized paper is listed with asterisks.

Typical Paper(s)

"A" Paper (16)
- a. 11" x 8.5"
- b. 12" x 9"
- c. 10.5" x 7.5" **

"B" Paper (8)
- a. 17" x 11"
- b. 18" x 12"
- c. 15" x 10.5" **

"C" Paper (4)
- a. 22" x 17"
- b. 24" x 18"
- c. 21" x 15" **

"D" Paper (2)
- a. 34" x 22"
- b. 36" x 24"
- c. 30" x 21" **

"E" Paper (1)
- a. 44" x 34"
- b. 48" x 36"
- c. 42" x 30" **

(#) = sheets in an "E" size sheet

** = nonstandard

Figure 2.67 Typical standard and nonstandard paper sizes.

Thus, if a final drawing is to be printed/plotted on an 8½″ × 11″ sheet of paper, its template in the computer should be called “A” paper, an 11″ × 17″ sheet of paper would be called “B” paper, and so on.

When drafting manually, the drafter has the entire sheet of paper to work with. Such is not the case with computer…generated drawings. The CAD drafter must be aware of the limits of the printer or plotter. For example, an 8½″ × 11″ paper may have a printable area of only 8″ × 10½″. This proportion holds true with all paper. When you add border lines and title blocks to the drawing sheet, the actual drawing area of the sheet will be reduced to a given standard used in the office. Figure 2.68 shows a diagram of the printable area and the drawing area of an 8½″ × 11″ sheet of paper.

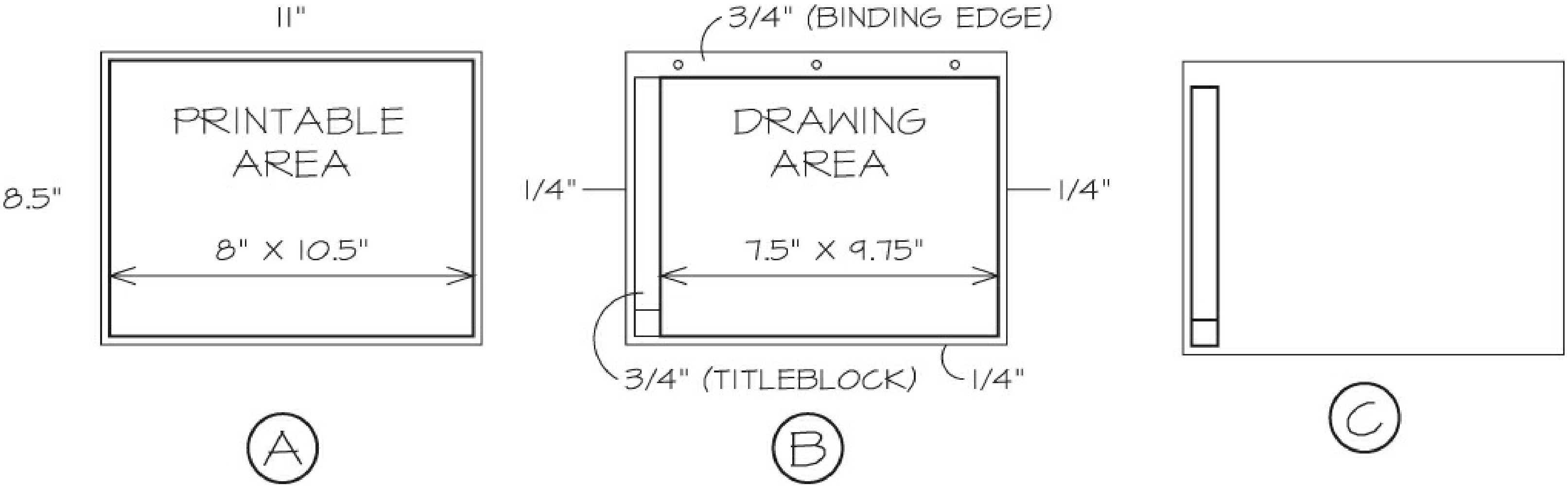


Figure 2.68 Printable and drawing area 8.5″ × 11″.

Knowing that the printable area for an 8½″ × 11″ sheet of paper can be 8″ × 10½″, ideally we would set the margins at ¼″ and use a 1″ or ¾″ strip for a title block. Some offices do not even print the borders, but only the title block. If the drawing will be bound, the binding edge is increased to ¾″, leaving a drawing area of 7½″ × 9¾″ (see Figures 2.77B and 2.77C, respectively).

Because most computer drawings are done in layers (layering is covered later in this chapter), one layer may contain the limits within which the drafter must stay. These borders may or may not be printed in the final drawing (see Figures 2.68A and 2.68C, respectively).

Paper larger than 8½″ × 11″ is subdivided into drawing modules. In Figure 2.69, a 24″ × 36″ sheet of paper is shown with a 1½″ left binding border and a ½″ border for the top, bottom, and right side. It will use a 1½″ title block. The remaining drawing area is divided into five horizontal and five vertical spaces, each of which is 4″ × 6½″. This now becomes the office standard for all drawings. Notes will be typed so as not to exceed 6½″ in width (or 13″ if two modules are used) and a vertical height of 4⅝″, 9¼″, 13¾″, 18″, or 22⅝″.

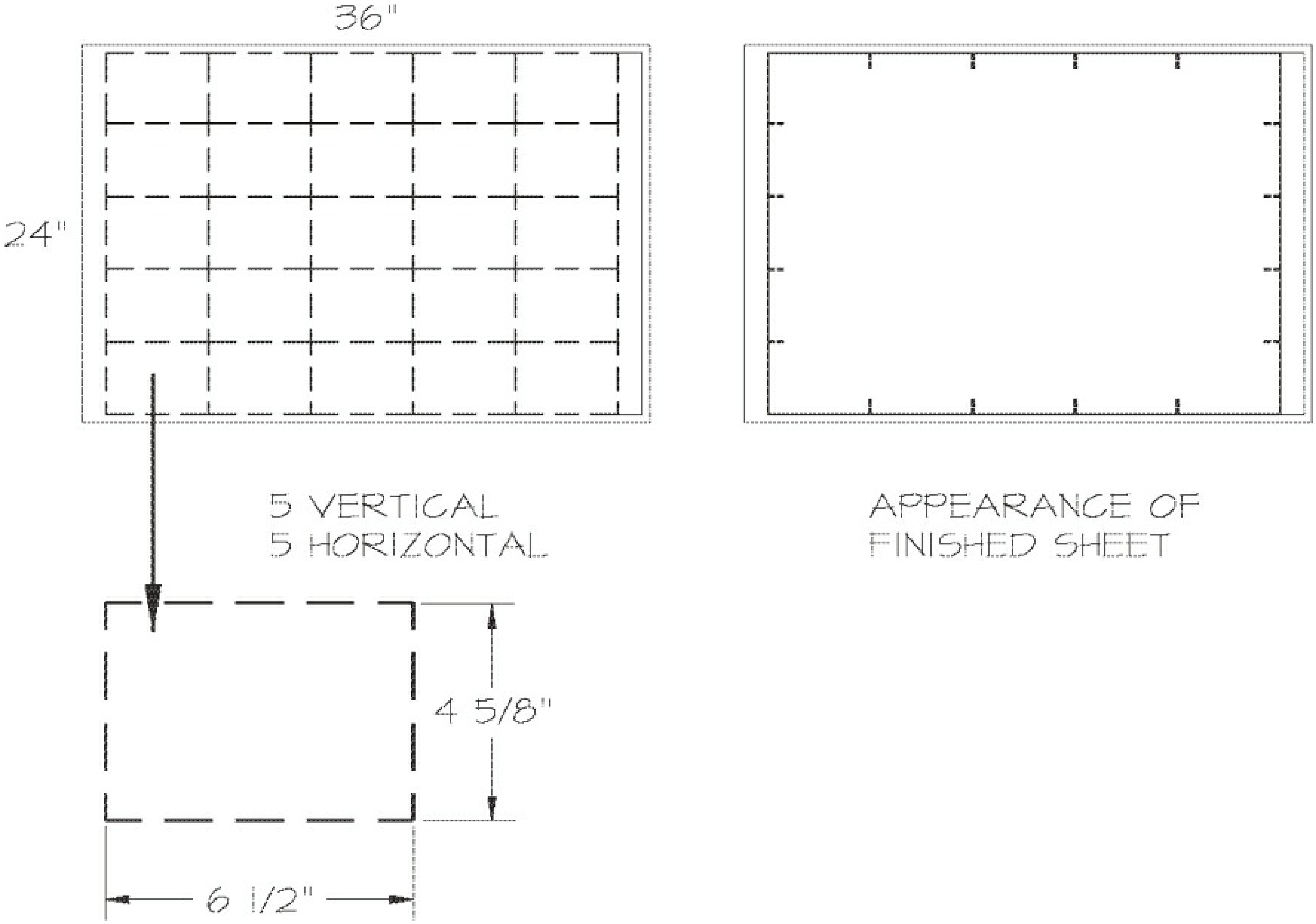


Figure 2.69 Drawing modules for 24″ × 36″.

Architectural details are drawn to this module of 4⅝″ × 6½″. This space may be further divided into drawing areas and keynote areas to further exploit paper usage.

Plans, elevations, building sections, and site plans should be drawn within this established matrix so as to allow the remaining space to be used by details, notes, charts, and schedules. Figure 2.70 shows a site plan, general notes, details, vicinity map, and an index formatted to a 24″ × 36″ sheet of paper with a matrix of five vertical and five horizontal modules.

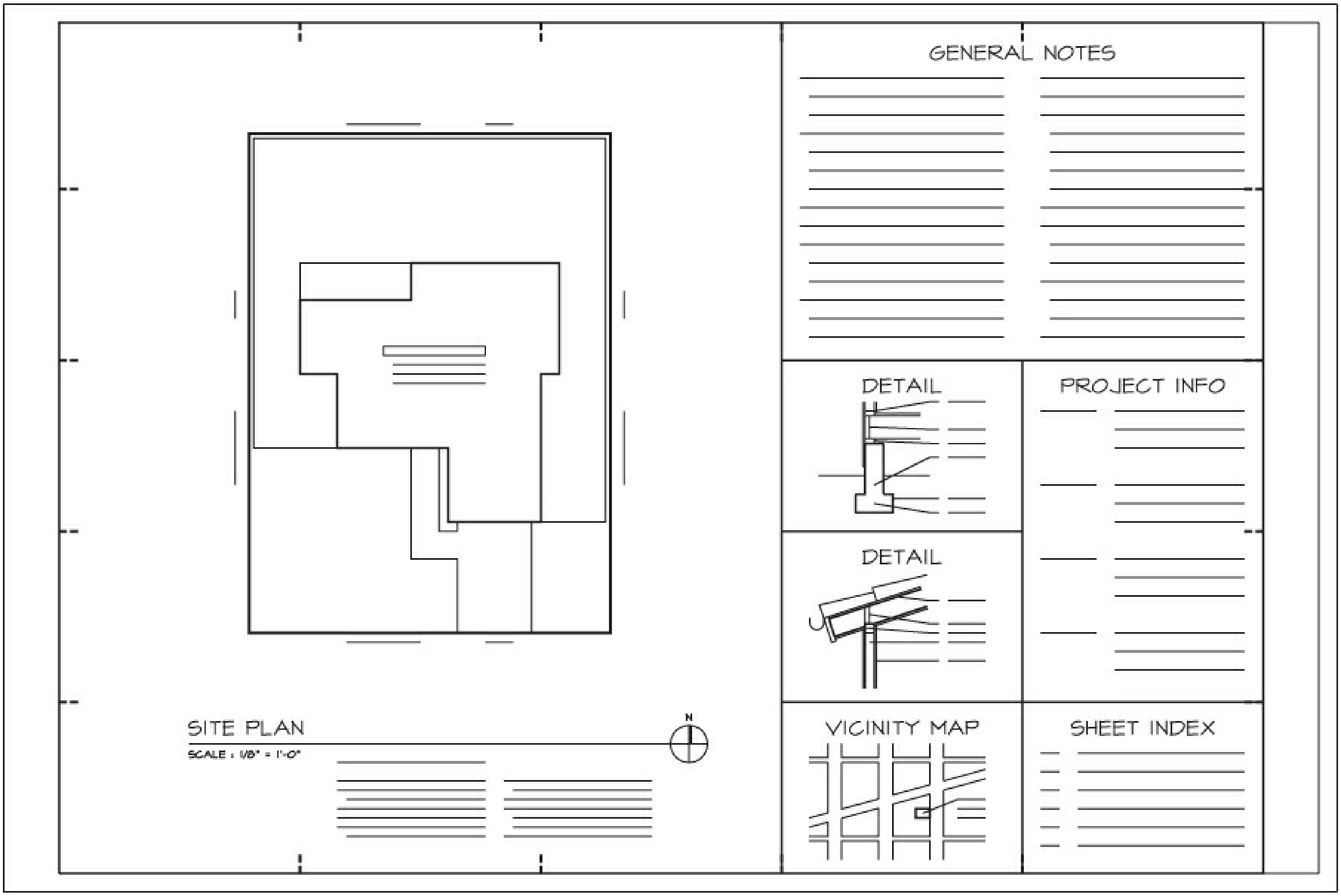


Figure 2.70 Drawing modules for 24″ × 36″ registered.

Figure 2.71 shows this formatting process using a 24″ × 36″ sheet divided into a 5 × 5 module and a 4 × 5 module, and a 30″ × 42″ sheet divided into a 5 × 5 module and a 6 × 6 module. Once the formatting process decision is made in the office, the drafter must comply with these limits when drawing, writing notes, and even detailing. If many drafters are working on one set of working drawings and all subscribe to a single format pattern, not only will the entire set look well organized to the client, but the integral pieces will fit together like a giant puzzle. Clear, precise drawings reduce office liability and increase the visual impact of office documents.

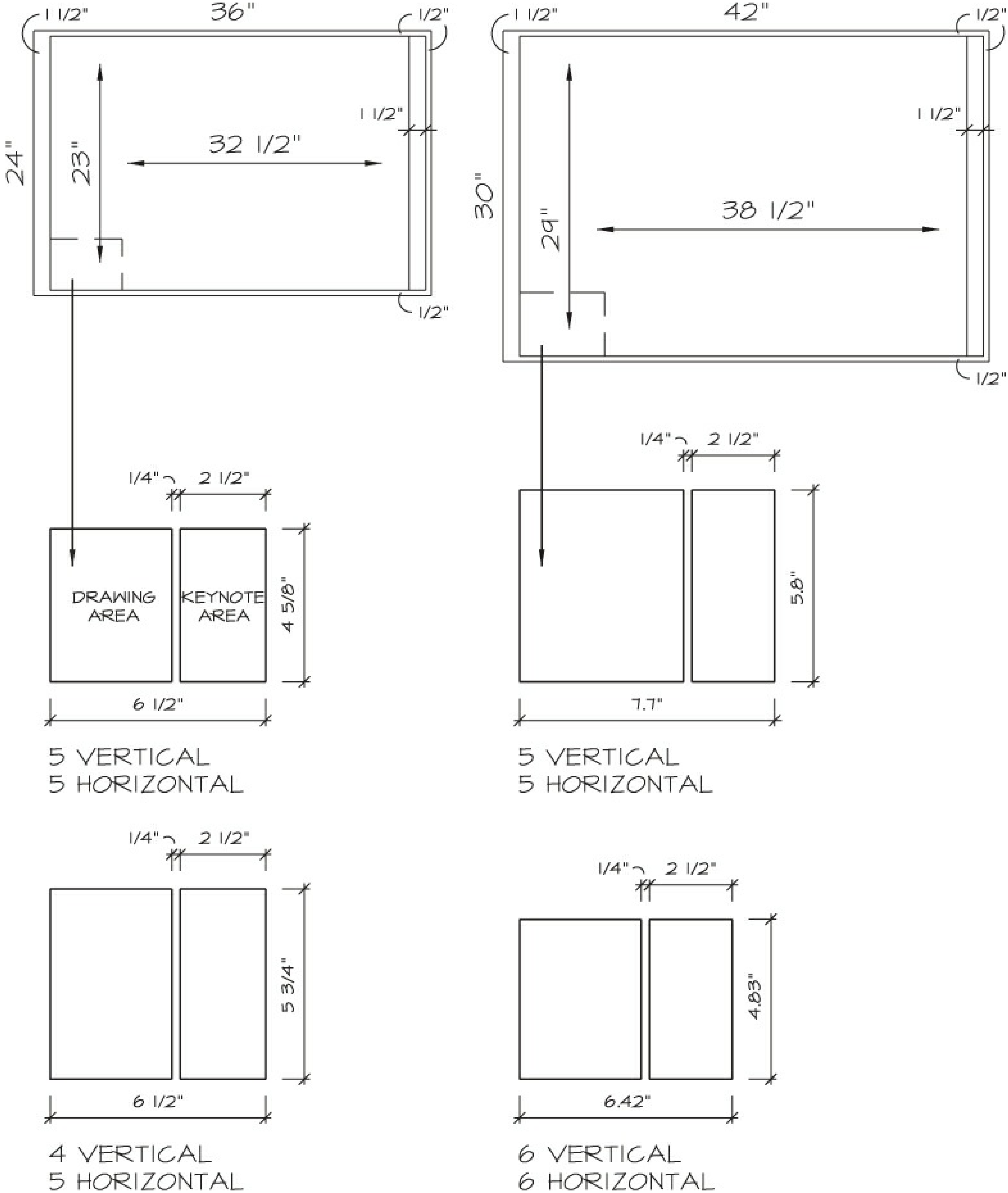


Figure 2.71 Detailing modules for 24″ × 36″ and 30″ × 42″.

As described earlier, a structure is drawn at full scale on the computer and viewed through a window that is actually the monitor. By filling this entire screen area with a

standard…size sheet of paper, you have a formatted screen ready to import drawings. The interior of this drawing sheet is now your new window, which is called a **viewport.** Each module can also be a viewport. Figure 2.72 shows a monitor displaying a 24″ × 36″ sheet of paper. Thus, a viewport becomes a window on the paper through which you can see a full…size building. The computer allows you to zoom up close or fill the viewport with a graphic image such as a floor plan. In this way, you can fill to the extents of the viewport, but you will not be displaying to any given scale.

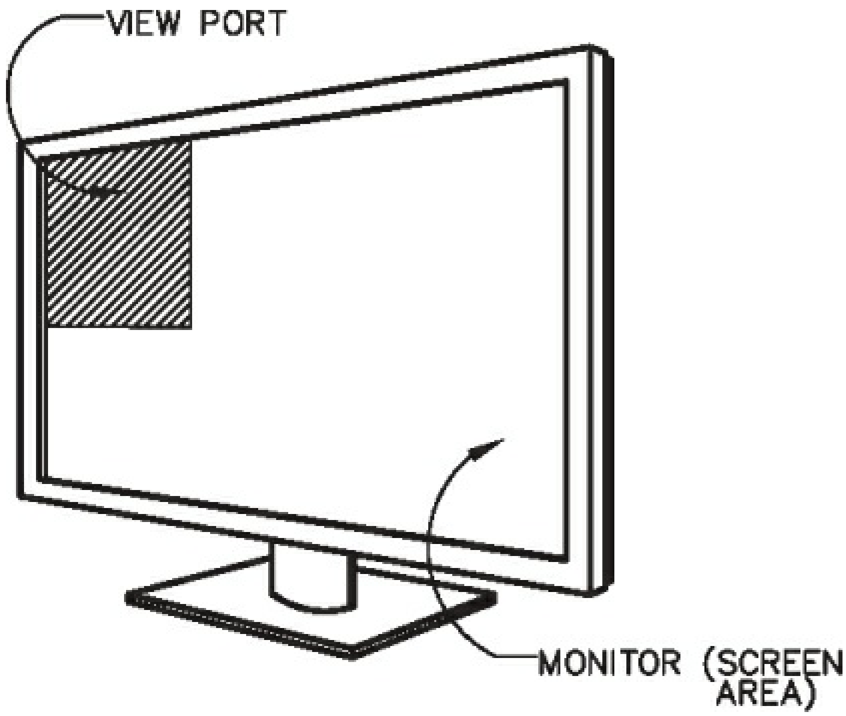


Figure 2.72 Monitor—paper space and viewport.

The best solution to this nonscaled drawing is to fill the viewport with the largest image possible, but to a known scale. This scale may be an architectural scale such as ⅛″ = 1′…0″ or 1⁄4″ = 1′…0″.

2‗D (Paper) versus 3‗D (Virtual or Model) Space. The difference between two…dimensional (2…D) and three…dimensional (3…D) space can be compared to the difference between manual drafting and computer…aided drafting. In paper (2…D) space, you fill the monitor with a theoretical piece of paper. This theoretical piece of paper is already unrealistic, because it is an image of the actual piece of paper reduced to fit the screen. In manual drafting, the paper is actual size.

In model space or virtual space (3…D), you are drawing full size. When you are "modeling" a drawing, you measure the size of the building exactly. You do not work at a reduced scale.

When printing or plotting a drawing, you must reduce this full…size drawing or model to a scale that will fit on the actual paper size. For this reason, we encourage you to draw structures in model space and draw them full scale. Model space, also called **virtual space,** is the closest thing to the real thing.

Figure 2.73 shows various sizes of paper and their drawing areas based on scale. Sizes of

paper range from a standard 8½″ × 11″ to a 36″ × 48″. These are listed across the top of Figure 2.73, and the various scales (architectural and engineering) are shown to the left. For example, if you were preparing a floor plan for a building 90′ deep and 135′ wide at a ¼″ = 1′…0″ scale (shaded area on chart) and wanted to find a paper sheet size, note that at the intersection of a 24″ × 36″ column and ¼″ = 1″ row, a 96″ × 144″ figure appears. This means that at a ¼″ scale, and using a 24″ × 36″ piece of paper, a 96′ × 144′ space is available. If a 70′ × 90′ building were to be drawn, it would occupy approximately 18″ × 24″ of the 24″ × 36″ sheet. The rest could be used for details, notes, or schedules.

	AP		BP		CP		DP		EP		FP	
(width) X"	11	8	17	14	24	21	36	33	48	45	42	39
(height) Y"	8.5	7.5	11	10	18	17	24	23	36	35	30	29
Scale	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ
3"=1'	3'8x2'10	2'8x2'6	5'8x3'8	4'8x3'4	8'x6'	7'x5'8	12'x8'	11'x7'8	16'x12'	15'x11'8	14'x10'	13'x9'8
1 1/2"=1'	7'4x5'8	5'4x5'	11'4x7'4	9'4x6'8	16'x12'	14'x11'4	24'x16'	22'x15'4	32'x24'	30'x23'4	28'x20'	26'x19'4
1"=1'	11'x8'6	8'x7'6	17'x11'	14'x10'	24'x18'	21'x17'	36'x24'	33'x23'	48'x36'	45'x35'	42'x30'	39'x29'
3/4"=1'	14'8x11'4	10'8x10'	22'8x14'8	18'8x13'4	32'x24'	28'x22'8	48'x32'	44'x30'8	64'x48'	60'x46'8	56'x40'	52'x38'8
1/2"=1'	22'x17'	16'x15'	34'x22'	28'x20'	48'x36'	42'x34'	72'x48'	66'x46'	96'x72'	90'x70'	84'x60'	78'x58'
1/4"=1'	44'x34'	32'x30'	68'x44'	56'x40'	96'x72'	84'x68'	144'x96'	132'x92'	192'x144'	180'x140'	168'x120'	156'x116'
1/8"=1'	88'x68'	64'x60'	136'x88'	112'x80'	192'x144'	168'x136'	288'x192'	264'x184'	384'x288'	360'x280'	336'x240'	312'x232'
1/16"=1'	176'x136'	128'x120'	272'x176'	224'x160'	384'x288'	336'x272'	576'x384'	528'x368'	768'x576'	720'x560'	672'x480'	624'x464'
1/32"=1'	352'x272'	256'x240'	544'x352'	448'x320'	768'x576'	672'x544'	1152'x768'	1056'x736'	1536'x1152'	1440'x1120'	1344'x960'	1248'x928'
3/32"=1'	117'6x90'6	85'6x80'	181'6x117'6	149'6x107'	299' x 192'	224' x 181'6	384'6x 256'	352'6x 245'6	512'6 x 384'6	480'6x373'6	448'6 x 326'	416'6x309'6

Architectural

	AP		BP		CP		DP		EP		FP	
(width) X"	11	8	17	14	24	21	36	33	48	45	42	39
(height) Y"	8.5	7.5	11	10	18	17	24	23	36	35	30	29
Scale	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ
1/10"=1'	110'x85'	80'x75'	170'x110'	140'x100'	240'x180'	210'x170'	360'x240'	330'x230'	480'x360'	450'x350'	420'x300'	390'x290'
1/20"=1'	220'x170'	160'x150'	340'x220'	280'x200'	480'x360'	420'x340'	720'x480'	660'x460'	960'x720'	900'x700'	840'x600'	780'x580'
1/25"=1'	275'x212'6	200'x187'6	425'x275'	350'x250'	600'x450'	525'x425'	900'x600'	825'x575'	1200'x900'	1125'x875'	1050'x750'	975'x725'
1/30"=1'	330'x255'	240'x225'	510'x330'	420'x300'	720'x540'	630'x510'	1080'x720'	990'x690'	1440'x1080'	1350'x1050'	1260'x900'	1170'x870'
1/40"=1'	440'x340'	320'x300'	680'x440'	560'x400'	960'x720'	840'x680'	1440'x960'	1320'x920'	1920'x1440'	1800'x1400'	1680'x1200'	1560'x1160'
1/50"=1'	550'x425'	400'x375'	850'x550'	700'x500'	1200'x900'	1050'x850'	1800'x1200'	1650'x1150'	2400'x1800'	2250'x1750'	2100'x1500'	1950'x1450'
1/60"=1'	660'x510'	480'x450'	1020'x660'	840'x600'	1440'x1080'	1260'x1020'	2160'x1440'	1980'x1380'	2880'x2160'	2700'x2100'	2520'x1800'	2340'x1740'
1/75"=1'	825'x637'6	600'x562'6	1275'x825'	1050'x750'	1800'x1350'	1575'x1275'	2700'x1800'	2475'x1725'	3600'x2700'	3375'x2625'	3150'x2250'	2925'x2175'
1/100"=1'	1100'x850'	800'x750'	1700'x1100'	1400'x1000'	2400'x1800'	2100'x1700'	3600'x2400'	3300'x2300'	4800'x3600'	4500'x3500'	4200'x3000'	3900'x2900'

Engineering

Adjusted Margins	
Top	0.5"
Bottom	0.5"
Left	1.5"
Right	0.5"
Title Rt.	1"
Title Bot.	0"

Figure 2.73 Paper space maximum.

Scaling Factor. Some computer programs are programmed to deal with scale. With these programs, the drafter can size or scale a drawing simply by typing in the scale desired or selecting a scale from a menu. For example, if you wish to print or draw a floor plan at ¼″ = 1′…0″ scale, you simply select this scale and the computer does the rest of the work.

Other programs call for a scaling factor to be used. The CAD drafter must be comfortable

with either system. Scaling factor is computed in reference to a foot (12 inches). For example, if a drawing is to be scaled at 1⁄4″ = 1′…0″, you divide 12″ by 1⁄4″. Forty…eight becomes the scaling factor for 1⁄4″ = 1′…0″.

Figure 2.74 lists scaling factors for a variety of the most typically used architectural and engineering scales. Figure 2.75 shows a 9″ × 12″ and a 24″ × 36″ piece of paper. Using a scaling factor (48) for a 1⁄4″ scale, the numbers in the parentheses indicate how many feet (at 1⁄4″ scale) are available on the 24″ × 36″ sheet of paper. Now go back to Figure 2.73 and see the figures repeated for a number of different…sized sheets of paper and a variety of scales. Next, the drafter must know the same information for the drawing area. See Figure 2.76 and compute.

Scale	Factor
1'=1'	1
3"=1'	4
1 1/2"=1'	8
1"=1'	12
3/4"=1'	16
1/2"=1'	24
1/4"=1'	48
1/8"=1'	96
1/16"=1'	192
1/32"=1'	384
1"=10'	120
1"=20'	240
1"=25'	300
1"=30'	360
1"=40'	480
1"=50'	600
1"=60'	720
1"=75'	900
1"=100'	1200
1"=200'	2400

Figure 2.74 Scaling factors.

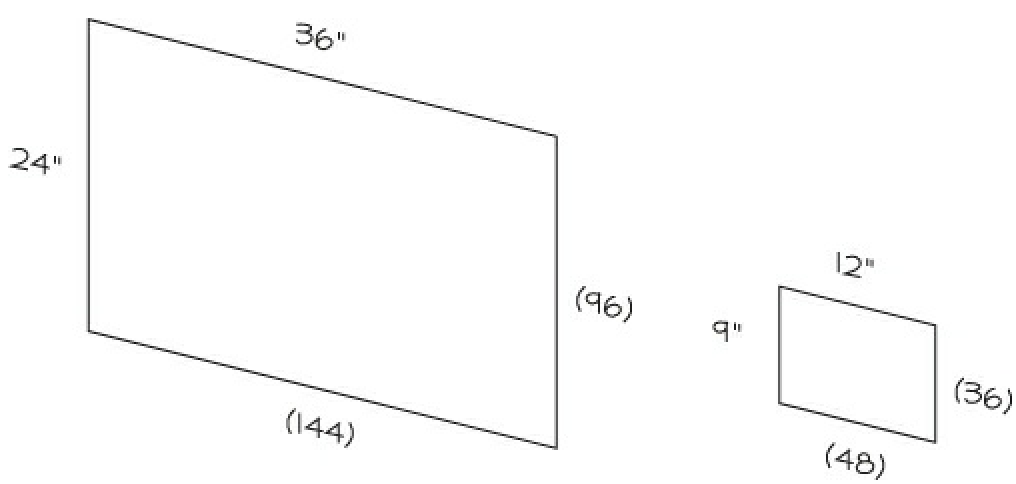


Figure 2.75 Scaling factor (1⁄4″) for 24″ × 36″ and 9″ × 12″.

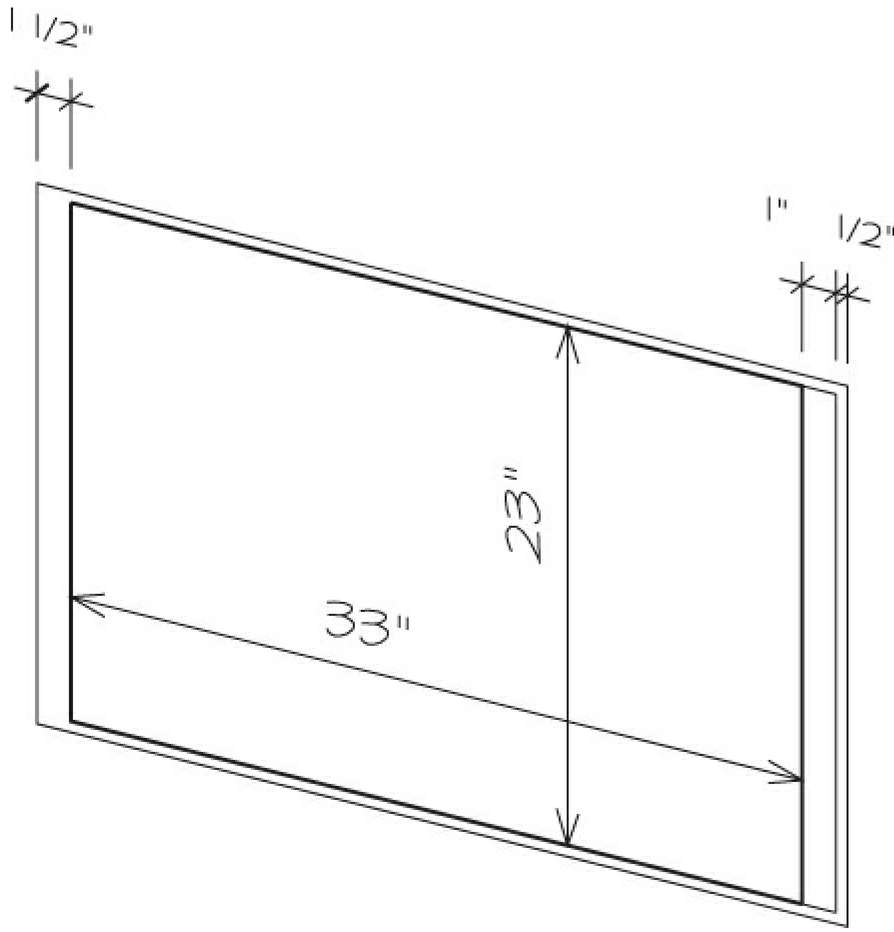


Figure 2.76 Printable area for 24″ × 36″ sheet.

Figure 2.77 shows the drawing area for a variety of scales and sheet sizes. The drawing area is now called the *viewport*.

			AP		BP		CP		DP		EP		FP	
		(width) X"	11	8	17	14	24	21	36	33	48	45	42	39
		(height) Y"	8.5	7.5	11	10	18	17	24	23	36	35	30	29
Factor	*Feet in 1"*	*Scale*	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ
4	1"=0'-4"	3"=1'	3'8x2'10	2'8x2'6	5'8x3'8	4'8x3'4	8'x6'	7'x5'8	12'x8'	11'x7'8	16'x12'	15'x11'8	14'x10'	13'x9'8
8	1"=0'-8"	1 1/2"=1'	7'4x5'8	5'4x5'	11'4x7'4	9'4x6'8	16'x12'	14'x11'4	24'x16'	22'x15'4	32'x24'	30'x23'4	28'x20'	26'x19'4
12	1"=1'-0"	1"=1'	11'x8'6	8'x7'6	17'x11'	14'x10'	24'x18'	21'x17'	36'x24'	33'x23'	48'x36'	45'x35'	42'x30'	39'x29'
16	1"=1'-4"	3/4"=1'	14'8x11'4	10'8x10'	22'8x14'8	18'8x13'4	32'x24'	28'x22'8	48'x32'	44'x30'8	64'x48'	60'x46'8	56'x40'	52'x38'8
24	1"=2'-0"	1/2"=1'	22'x17'	16'x15'	34'x22'	28'x20'	48'x36'	42'x34'	72'x48'	66'x46'	96'x72'	90'x70'	84'x60'	78'x58'
48	1"=4'-0"	1/4"=1'	44'x34'	32'x30'	68'x44'	56'x40'	96'x72'	84'x68'	144'x96'	132'x92'	192'x144'	180'x140'	168'x120'	156'x116'
96	1"=8'-0"	1/8"=1'	88'x68'	64'x60'	136'x88'	112'x80'	192'x144'	168'x136'	288'x192'	264'x184'	384'x288'	360'x280'	336'x240'	312'x232'
192	1"=16'-0"	1/16"=1'	176'x136'	128'x120'	272'x176'	224'x160'	384'x288'	336'x272'	576'x384'	528'x368'	768'x576'	720'x560'	672'x480'	624'x464'
384	1"=32'-0"	1/32"=1'	352'x272'	256'x240'	544'x352'	448'x320'	768'x576'	672'x544'	1152'x768'	1056'x736'	1536'x1152'	1440'x1120'	1344'x960'	1248'x928'

Architectural

			AP		BP		CP		DP		EP		FP	
		(width) X"	11	8	17	14	24	21	36	33	48	45	42	39
		(height) Y"	8.5	7.5	11	10	18	17	24	23	36	35	30	29
Factor	*Feet in 1"*	*Scale*	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ	TRUE	ADJ
120	1"=10'	1/10"=1'	110'x85'	80'x75'	170'x110'	140'x100'	240'x180'	210'x170'	360'x240'	330'x230'	480'x360'	450'x350'	420'x300'	390'x290'
240	1"=20'	1/20"=1'	220'x170'	160'x150'	340'x220'	280'x200'	480'x360'	420'x340'	720'x480'	660'x460'	960'x720'	900'x700'	840'x600'	780'x580'
300	1"=25'	1/25"=1'	275'x212'6	200'x187'6	425'x275'	350'x250'	600'x450'	525'x425'	900'x600'	825'x575'	1200'x900'	1125'x875'	1050'x750'	975'x725'
360	1"=30'	1/30"=1'	330'x255'	240'x225'	510'x330'	420'x300'	720'x540'	630'x510'	1080'x720'	990'x690'	1440'x1080'	1350'x1050'	1260'x900'	1170'x870'
480	1"=40'	1/40"=1'	440'x340'	320'x300'	680'x440'	560'x400'	960'x720'	840'x680'	1440'x960'	1320'x920'	1920'x1440'	1800'x1400'	1680'x1200'	1560'x1160'
600	1"=50'	1/50"=1'	550'x425'	400'x375'	850'x550'	700'x500'	1200'x900'	1050'x850'	1800'x1200'	1650'x1150'	2400'x1800'	2250'x1750'	2100'x1500'	1950'x1450'
720	1"=60'	1/60"=1'	660'x510'	480'x450'	1020'x660'	840'x600'	1440'x1080'	1260'x1020'	2160'x1440'	1980'x1380'	2880'x2160'	2700'x2100'	2520'x1800'	2340'x1740'
900	1"=75'	1/75"=1'	825'x637'6	600'x562'6	1275'x825'	1050'x750'	1800'x1350'	1575'x1275'	2700'x1800'	2475'x1725'	3600'x2700'	3375'x2625'	3150'x2250'	2925'x2175'
1200	1"=100'	1/100"=1'	1100'x850'	800'x750'	1700'x1100'	1400'x1000'	2400'x1800'	2100'x1700'	3600'x2400'	3300'x2300'	4800'x3600'	4500'x3500'	4200'x3000'	3900'x2900'

Engineering

Figure 2.77 Paper sizes at specific scales (½″ top, bottom, and right border, 1½″ left

border, 1″ right title…block space).

Layering. **Layering** is what makes computer drafting so superior to manual drafting. Layering is the process of creating a series of overlays on which you display different functions and different types of lines and conventions. The alignment of computer…generated layers is perfect. Selection of the proper layers is done in seconds. Layers may be turned on and off, frozen in place, plotted or not plotted. They can also be grouped and XREFed from other drawings.

Let us now look at a typical set of layers for a construction document. The first layer is often considered the base, unless you are using XREF drawings as a base. This first layer contains the matrix that will act as a datum for the entire drawing. For example, a steel building such as the Madison Building (see Chapter 6) is based on an axial reference system. A matrix locates and positions the steel columns. The matrix will be drawn on the base layer, with the steel columns possibly on the subsequent layer. This base (the datum) can be used for other drawings, so different views subscribe to the same system. Therefore, it becomes even more important that the drafter of tomorrow become familiar with three…dimensional datum drawings (described earlier) so that elevations, building sections, framing plans, and foundation plans can use the same base (datum) layer. In this way, we can cross…reference drawings from the very beginning (XREF drawings).

Each layer can be done in a different color. The use of various colors helps the drafter stay focused on the specific layer on which a particular task is to be accomplished. Colors also help in identifying drawings. Color also has an impact on the quality of lines, as explained in the next section.

If there is an inherent geometry present in the drawing but not used in the finished drawing, the construction lines can be drawn on a layer but never printed, A…NOH plotting layer. Take the case of drawing a winding stair, as shown in Figure 2.78. The construction lines are on one layer, and the drawing of the stair is on another. One need only outline the required portions of the geometry to produce a base drawing, and then repeat the forms to produce the finished drawing.

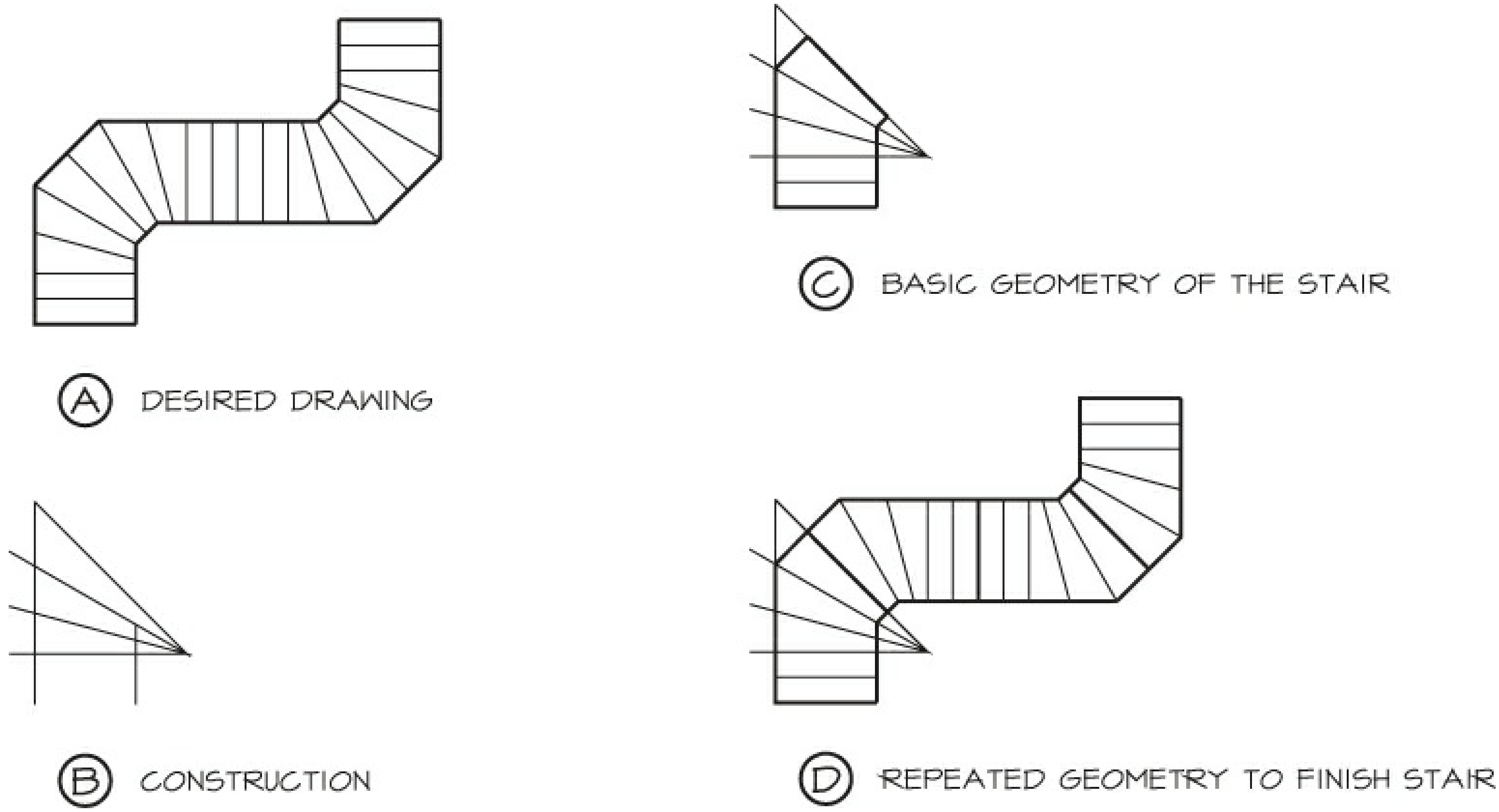


Figure 2.78 Diagnosing geometry (stair).

Setting Up Layers. Look again at the sample of layers and their specific titles in Figure 2.61. Although this is a simplified plan, it does follow many of the examples found in the national CAD standards pamphlet. Notice the legend and the letter designations for architectural, mechanical, structural, and so on. Learn to identify the standards so that you can tell the difference between correctly and incorrectly drawn documents.

Correct and uniform titles are important, because as you are laying out the structural members of a building, these members must be cross…referenced with the electrical conduit on the electrical drawing, or the heating or air…conditioning ducts found on the mechanical set, that may occupy the same space.

The strategy employed might be staged similarly to that in Figure 2.79. Note the number of layers produced on the left side, the composite drawing for construction in the center, and the drawing used for client consumption on the right side. Note the inclusion of the furniture layer for client consumption and the voiding of the dimensioning layer on the same set.

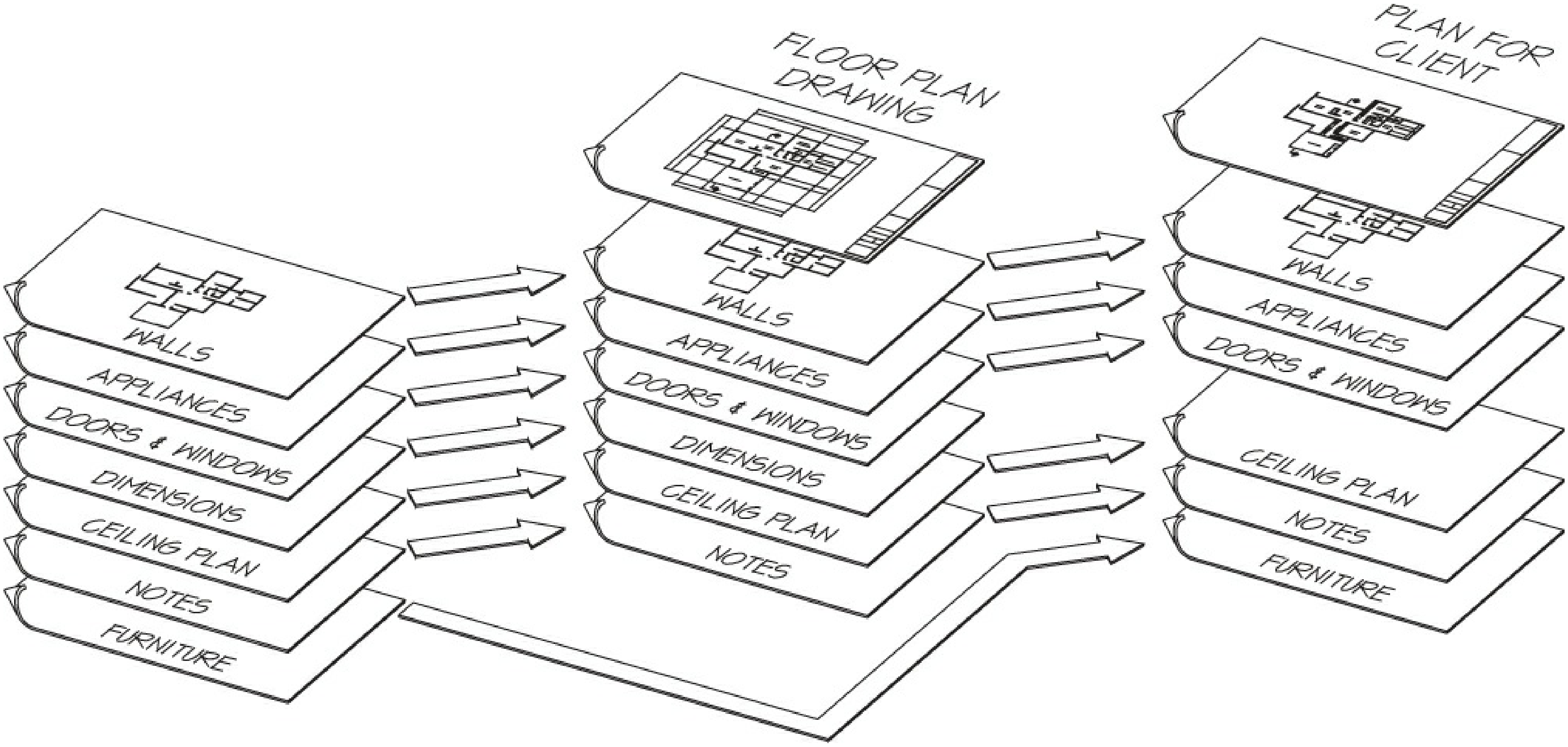


Figure 2.79 Example of the planning for a single file.

In the multifile strategy illustrated in Figure 2.80, an example of a three…file system is shown. File #1 is the architectural file, which we just looked at in Figure 2.79. File #2 is a structural set, and File #3 is a lighting plan. Note how various layers are selected to produce still another file. In this example, File #4 becomes a lateral plan, and File #5 becomes the reflected ceiling plan. As indicated earlier, this process is called "XREFing."

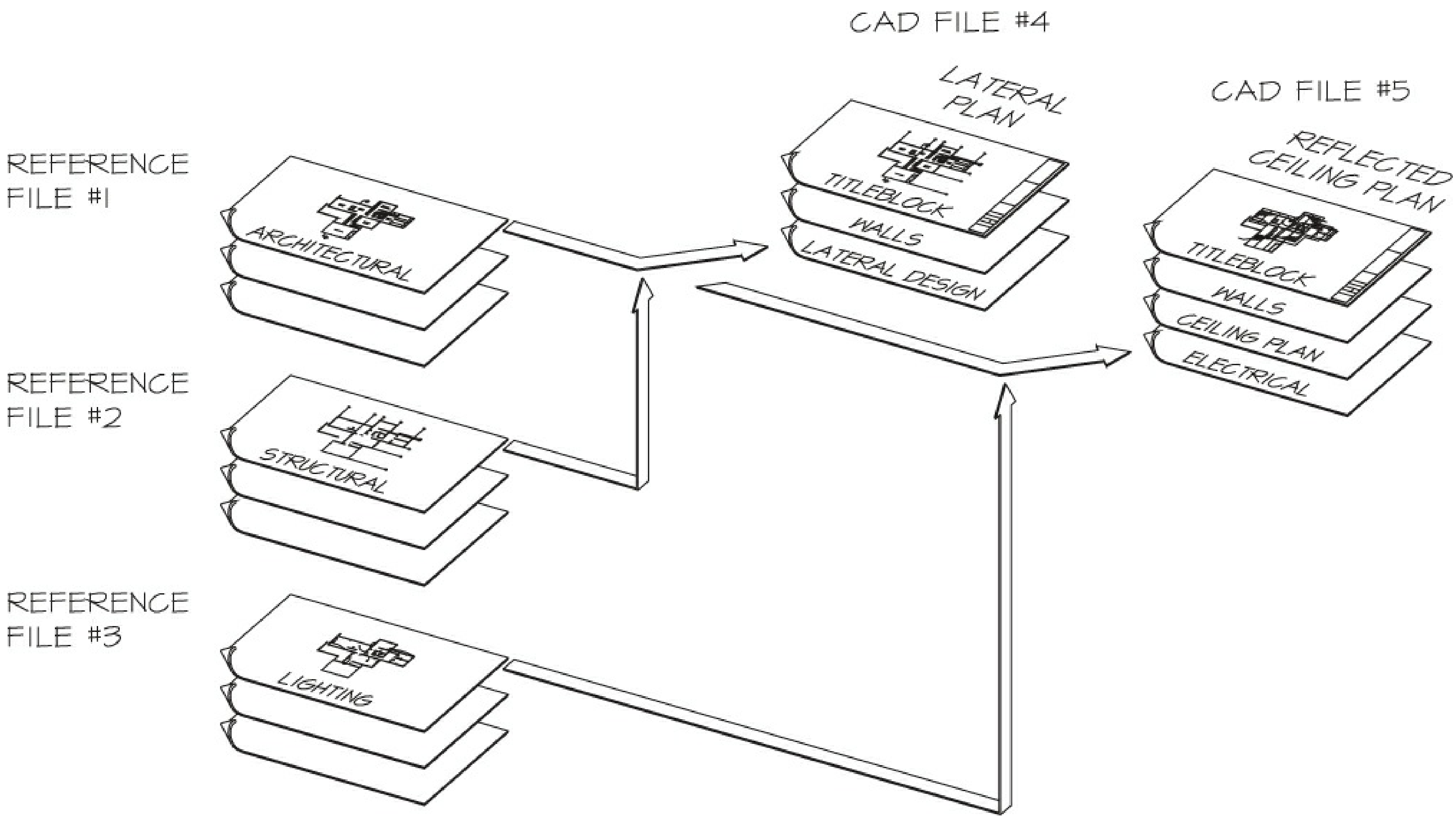


Figure 2.80 Example of planning for multiple files.

Updating Old Drawings in CAD. To update an existing drawing, simply import an old CAD drawing. Retitle the drawing, erase the portions that do not apply, make the corrections on a new layer, and complete the drawing. In this fashion, you will preserve the original drawing in the office's archive. Remember that merely saving the drawing on a flash drive, CD, or DVD will preserve it for about five to seven years. Put the saved drawing on an archivable CD or exterior hard drive to save space in your computer.

Pen Setting and Line Weights. Line weights can be produced by establishing and assigning certain colors as desired pen settings. Figure 2.81 shows common AutoCAD pen settings. The number assigned to the pen can be found on the extreme left side of the chart. Directly adjacent to the pen number is the name of the pen. The names are names of colors. As you can see by the width of the pens, magenta is the strongest and should be used for object lines. The thinnest line is red.

Pen Settings

color	name	width
1	red	0.008
2	yellow	0.012
3	green	0.008
4	cyan	0.010
5	blue	0.012
6	magenta	0.030
7	white (high ink)	0.020
8	dark gray	0.015
9	light gray	0.015
15	dark red	0.012
30	orange	0.008
174	dark blue	0.010
250	dark gray	0.015
251	med. dark gray	0.015
252	med. gray	0.015
253	med. light gray	0.015
254	light gray	0.015
255	white (low ink)	0.015

Figure 2.81 Pen settings, line weights, and colors.

The office may have already established these standards, which may be based on a national standard. You need to know the source and why the office standards were established in this fashion. Knowing why allows you to know the office's game plan.

Pen settings and line weights should be saved on the computer or disk immediately when establishing the layers so that you can employ them as needed.

Figure 2.82 is a summary chart of the items discussed in this section. Sample standard titles are listed to the left, then the colors used, followed by the line types and descriptions of their uses.

NAME	COLOR	LINETYPE	DESCRIPTION
0	WHITE	Continuous	For making Blocks & Unknown
ANNO	CYAN	Continuous	Text (annotation)
ANNO-DIMS	RED	Continuous	Dimensions
ANNO-IDEN	YELLOW	Continuous	Identification (rooms)
ANNO-KEYN	CYAN	Continuous	Keynotes
ANNO-LEGN	CYAN	Continuous	Legends and Schedules
ANNO-NOTE	CYAN	Continuous	General Notes
ANNO-PATT	RED	Continuous	Hatches (all)
ANNO-PCHE	8 (lt) or 9 (dk)	Continuous	Poche (all)
ANNO-REDL	RED	Continuous	Redlines (corrections to be made)
ANNO-SYMB	YELLOW	Continuous	Symbols (scale, north, section)
ANNO-TTLB	CYAN	Continuous	Title block
ANNO-VIEW	RED	Continuous	Viewports
DOOR	CYAN	Continuous	Doors (plan & elevation)
ELEC	YELLOW	Continuous	Electrical Symbols
ELEC-CONN	CYAN	CENTER2	Electrical Connections
ELEV	CYAN	Continuous	Elevation (colors can vary)
ELEV-BYND	BLUE	Continuous	Objects Beyond
ELEV-OTLN	WHITE	Continuous	Building Outline/Profile
FLOR	CYAN	Continuous	Floor plan (secondary information)
FLOR-DECK	YELLOW	Continuous	Deck
FLOR-HIDD	RED	HIDDEN	Hidden
FLOR-HRAL	RED	Continuous	Handrails & Balcony Railings
FLOR-STRS	CYAN	Continuous	Stairs
FNDN	YELLOW	HIDDEN	Foundation (footings & pads)
FNDN-SHRW	MAGENTA	Continuous	Shearwall
FNDN-SLAB	WHITE	Continuous	Slab
FRAM	YELLOW	Continuous	Framing (posts, headers, rafters)
FRAM-BEAM	WHITE	CENTER	Beams (wood, steel, prefab)
FRAM-JOIS	CYAN	CENTER2	Ceiling Joists
FRAM-SHRW	MAGENTA	Continuous	Shearwall
GLAZ	CYAN	Continuous	Windows (plan & elevation)
ROOF	WHITE	Continuous	Roof Outline (ridges, hips, valleys)
ROOF-BLDG	RED	DASHED	Building Outline
ROOF-OTHR	CYAN	Continuous	Roof (vent, chimney, skylight, etc)
SECT	CYAN	Continuous	Section (colors can vary)
SECT-BYND	BLUE	Continuous	Objects Beyond
SECT-OTLN	WHITE	Continuous	Objects at Section Cut/Profile
SITE	CYAN	Continuous	Site
SITE-BLDG	WHITE	Continuous	Building Outline
SITE-EXST	RED	Continuous	Existing Information
SITE-PLNT	GREEN	Continuous	Plants/Landscape
SITE-PROP	MAGENTA	PHANTOM	Property Line
SITE-RTWL	YELLOW	Continuous	Retaining Wall
TOPO	GREEN	DASHED	Topography (from surveyor)
TOPO-OTHR	BLUE	DASHED2	Topography (faded)
WALL	WHITE	Continuous	Wall (full height)
WALL-HALF	YELLOW	Continuous	Wall (partial height)
XREF	WHITE	Continuous	Cross-Referenced Files (XREFs)
XREF-GHST-OTHER	BLUE	Continuous	Ghost - faded (fixtures, labels, etc)
XREF-GHST-WALL	RED	Continuous	Ghost - light (walls, stairs, etc)

Figure 2.82 Sample preliminary documentation of office layering standard.

Lettering Size. One advantage of a computer is its ability to change scale rapidly. The disadvantage appears, for example, in drawing a floor plan at 1⁄4″ = 1′…0″ scale with 1⁄8″ tall lettering, then reducing it to a 1⁄8″ = 1′…0″ scale without any regard to the final height of the lettering. The lettering in this example will be 1⁄16″ tall and very difficult to read, not to mention that it will not follow the office standard and will look peculiar in a set of drawings.

Graphic scales are often used in lieu of expressing the scale in a proportion (see Figure 2.83A).

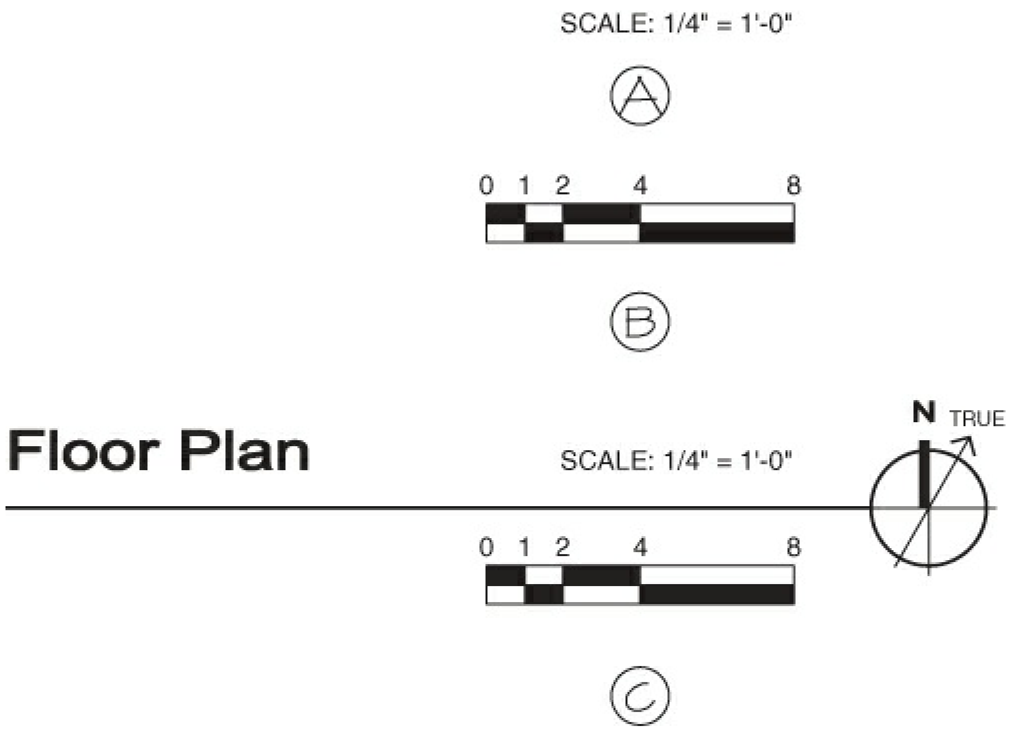


Figure 2.83 Numerical scale versus graphic scale.

Because we are drawing in model space (virtual space), we are able to draw the structure at full scale. However, every drafter must realize the scale to which the drawing will be reduced and printed. For example, a floor plan can be drawn at full scale but may be reduced to 1⁄4″ = 1′…0″ scale when printed on a 24″ × 36″ sheet of paper. Knowing the final display scale is important because when notes and dimensions are placed on the final print, they must be readable. If the office standard is to have lettering that is 1⁄8″ tall, with titles 1⁄4″ tall, this lettering height must be translated into a measurement that is full size because we are drawing in full size. At 1⁄4″ = 1′…0″, all lettering (1⁄8″ in height) must be scaled at 6″ tall and the titles (1⁄4″ tall) at 1′…0″ because the lettering height is measured in scale. For your convenience, two charts, an engineering scale and an architectural scale, are included to help translate various lettering heights to specific heights (see Figure 2.84).

Architectural

Scale:	3"=1'	1 1/2"=1'	1"=1'	3/4"=1'	1/2"=1'	1/4"=1'	1/8"=1'	1/16"=1'	1/32"=1'
Feet in 1":	1"=0'-4"	1"=0'-8"	1"=1'-0"	1"=1'-4"	1"=2'-0"	1"=4'-0"	1"=8'-0"	1"=16'-0"	1"=32'-0"
Scale Factor:	4	8	12	16	24	48	96	192	384
1" Text	4"	8"	12"	16"	24"	48"	96"	192"	384"
3/4" Text	3"	6"	9"	12"	18"	36"	72"	144"	288"
1/2" Text	2"	4"	6"	8"	12"	24"	48"	96"	192"
3/8" Text	1.5"	3"	4.5"	6"	9"	18"	36"	72"	144"
1/4" Text	1"	2"	3"	4"	6"	12"	24"	48"	96"
3/16" Text	0.75"	1.5"	2.25"	3"	4.5"	9"	18"	36"	72"
1/8" Text	0.5"	1"	1.5"	2"	3"	6"	12"	24"	48"
3/32" Text	0.375"	0.75"	1.125"	1.5"	2.25"	4.5"	9"	18"	36"
1/16" Text	0.25"	0.5"	0.75"	1"	1.5"	3"	6"	12"	24"

Engineering

Scale:	1/10"=1'	1/20"=1'	1/25"=1'	1/30"=1'	1/40"=1'	1/50"=1'	1/60"=1'	1/75"=1'	1/100"=1'
Feet in 1":	1"=10'	1"=20'	1"=25'	1"=30'	1"=40'	1"=50'	1"=60'	1"=75'	1"=100'
Factor:	120	240	300	360	480	600	720	900	1200
1" Text	120"	240"	300"	360"	480"	600"	720"	900"	1200"
3/4" Text	90"	180"	225"	270"	360"	450"	540"	675"	900"
1/2" Text	60"	120"	150"	180"	240"	300"	360"	450"	600"
3/8" Text	45"	90"	112.5"	135"	180"	225"	270"	337.5"	450"
1/4" Text	30"	60"	75"	90"	120"	150"	180"	225"	300"
3/16" Text	22.5"	45"	56.25"	67.5"	90"	112.5"	135"	168.75"	225"
1/8" Text	15"	30"	37.5"	45"	60"	75"	90"	112.5"	150"
3/32" Text	11.25"	22.5"	28.125"	33.75"	45"	56.25"	67.5"	84.375"	112.5"
1/16" Text	7.5"	15"	18.75"	22.5"	30"	37.5"	45"	56.25"	75"

Figure 2.84 Text size for architectural/engineering drawings.

The scale in which you will print/plot your drawing is read across the top of each chart. The desired height of the final text is read down the left column. The intersection of these columns will tell you the height of the lettering. See the shaded area for the ⅛″ tall lettering at 1⁄4″ = 1′…0″ scale for the previous example.

The decimal conversion chart in Figure 2.85 includes the height of lettering in decimals. As every schoolchild knows, ½″ is equal to 0.5″, but equivalents for fractions such as 3⁄16 and 3⁄32 are hard to remember; they are 0.1875 and 0.09375, respectively.

Standard Text Sizes

Standard Text		Optional Text	
1"	1	3/4"	0.75
1/2"	0.5	3/8"	0.375
1/4"	0.25	3/16"	0.1875
1/8"	0.125	3/32"	0.09375
1/16"	0.0625	3/64"	0.046875
1/32"	0.03125		

Figure 2.85 Conversion chart for simple fraction to decimal.

Standards are established for general noting, room titles, and the title of the drawing. For example, it is a prevalent practice to use upper… and lowercase lettering for the title of a drawing, such as “Floor Plan.” The font may be Helvetica. Room titles may be in all caps, using the same Helvetica font. Notes and general text should be done in all caps but in an architectural font. An architectural font can simulate a hand…lettered drawing, thus giving the drawing a distinguishing characteristic that separates it from engineering drawings. There are two additional reasons for using an architectural font. Architectural fonts, as compared with other textbook…type fonts, are described by a simpler geometry. Because the shape definition uses less geometry, it prints faster.

The other reason to use an architectural font is that, because it simulates hand lettering, simple corrections can be done by hand when the computer is down or when speed is of the essence. Of course, the corrections must eventually be done on the computer, because manual corrections will not be reflected in the digital image saved on the computer or peripheral storage device.

Power of the CAD Drafter

The power of the CAD drafter at all levels lies not only in understanding the process of how buildings are built, which this book is mainly about, but also in the ability to produce the documents necessary to make this process a reality. To that end, all CAD drafters must:

1. Be divided into different levels of proficiency. Table 2.1 defines the four basic levels of CAD drafting found in an architectural office and their requirements. Level 1 is the equivalent of a junior drafter. Level 2 may be equated to the journeyman drafter, and Level 3 is considered a senior drafter. Level 4 is reserved for management.

Table 2.1 CAD Drafting in an Architectural Office

Level 1 One Semester Junior Drafter	Level 3 3rd Semester Senior Drafter
1. Ability to hardline a designer's ideas 2. Mastery of simple commands such as a. LINC, PLINC, DLINC, MLINC b. MOVE, COPY, SCALE c. TRIM, EXTEND, STRETCH d. INSFRT BLOCKS e. HATCHING f. DTEXT, MTEXT	1. Attributes 2. Finding architectural/structural errors based on experience 3. Manage individuals & objects (ability to hand off work) 4. Advanced 3…D Modeling/Visualization (through understanding of model Centric Design) 5. Thorough understanding of architectural/structural detailing 6. Complete Plan Check revisions (research

3. Basic 3…D modeling 4. Use of Object Snaps 5. Ortho & Polar restrictions 6. Keyboard entry(absolute & relative modes) 7. Basic Plan Check revisions(notes minor geometry changes) 8. File Management 9. Layering 10. Dimensions 11. Basic Plotting	& change entire working drawings) 7. Suggest/Modify page setups & templates 8. Basic Program Customization 9. Basic Programming 10. Advanced Rendering 11. Intermediate Plotting
Level 2 2nd Semester Journeyman Drafter	Level 4 4th Semester CADD Manager
1. XREF 2. Paperspace/Modelspace 3. Can follow a design change 4. Make appropriate design suggestions 5. Text Styles & Justifications 6. Intermediate 3…D Modeling (including Model Based/Model Centric Design) 7. Editing of Attributes 8. Filtering 9. Use of Object I racking 10. Advanced plan check revisions (new geometry/multiple sheets) 11. Program Preferences 12. Basic Poltting	1. Network/Hardware/Software installation, upgrades & troubleshooting 2. Image editing & Photo manipulation 3. Template construction 4. Titleblock Construction 5. Custom Blocks/Symbols 6. CustomHatches & Shapes 7. Ability to make purchase suggestions/decisions 8. Ability to make Implement & suggest changes to Office Standards 9. Internet & website development 10. Graphic Design skills 11. Advanced Program Customization 12. Advanced Programming 13. Advanced Plotting 14. Advanced Collaboration & Workgroup Tools (LAN/WAN/Internet)

2. Be comfortable working with any version of CAD, not just the latest version. Software programs change so often that it is very difficult to standardize the profession to work

in any computer application.

3. As you move from office to office, you may be confronted with a wide range of programs. We all know that as soon as a 2017 version of any program hits the market, the 2018 version is not far behind.
4. Be aware of the program their associates are using because it does little good to send them drawings that they cannot manipulate or use.
5. Be comfortable with drawing in full scale (model space) and plotting in paper space.
6. Be able to send and receive drawings via the computer as easily as making a telephone call; send drawing files that can be opened to receive additional information from their associates; or send closed files for viewing only, to protect the office.
7. Be able to draw in 3…D and rotate the 3…D drawing into orthogonals and produce 2…D drawings from them.
8. Be able to work on two different versions of a program without any loss of productivity.
9. Be able to manage their files and know how to compress their files.

The next level of CAD drafter is a person who can organize and initiate new programs in the office system using existing office standards. The third level of CAD drafter is a person who can troubleshoot the computer and do minimal repair. The final level of computer specialist is the person who can rewrite existing software programs to make them more effective tools for the office.

Disadvantages of a Computer

One of the greatest concerns in the industry is the piracy of drawings. Drawings sent electronically can be copied and duplicated. There is always a possibility that people who are changing jobs may download entire libraries of information and take that information with them to their new firms. Drawings can also be changed or altered. For this reason, many municipalities require a hard copy (printed on paper) with wet ink signatures.

The computer is constantly changing. The life cycle of a computer is said to be three years. Small offices, which are the majority in the architectural industry, cannot financially afford to change computers that frequently.

The percentage of downtime, which is the period when a computer or network is not operational for one reason or another, is still high and creates a problem for small offices with few computers. The development of better and faster computers is helping to reduce the amount of downtime, but it is for this reason that offices need a CAD manager.

Advantages of a Computer

The first advantage with a computer is that you are drawing full size. Fifty…foot…long buildings are drawn 50 feet in length. This is possible because we are drawing in model

(virtual) space, which is unlimited. Drafters can now think and measure full‥size buildings in actual dimensions, rather than in a reduced scale.

Another advantage is the computer's ability to enlarge or reduce a drawing instantly. A single drawing can be reproduced in a variety of different scales. The computer has the capability to enlarge and reduce, much like a paper copier.

A drawing can be displayed on the monitor as a single drawing, or the screen can be split and the original drawing can be displayed adjacent to an enlargement (see Figure 2.86). Two monitors can also be used simultaneously: one displaying the original drawing and the second monitor zooming in to show an enlargement of a given area (see Figure 2.87).

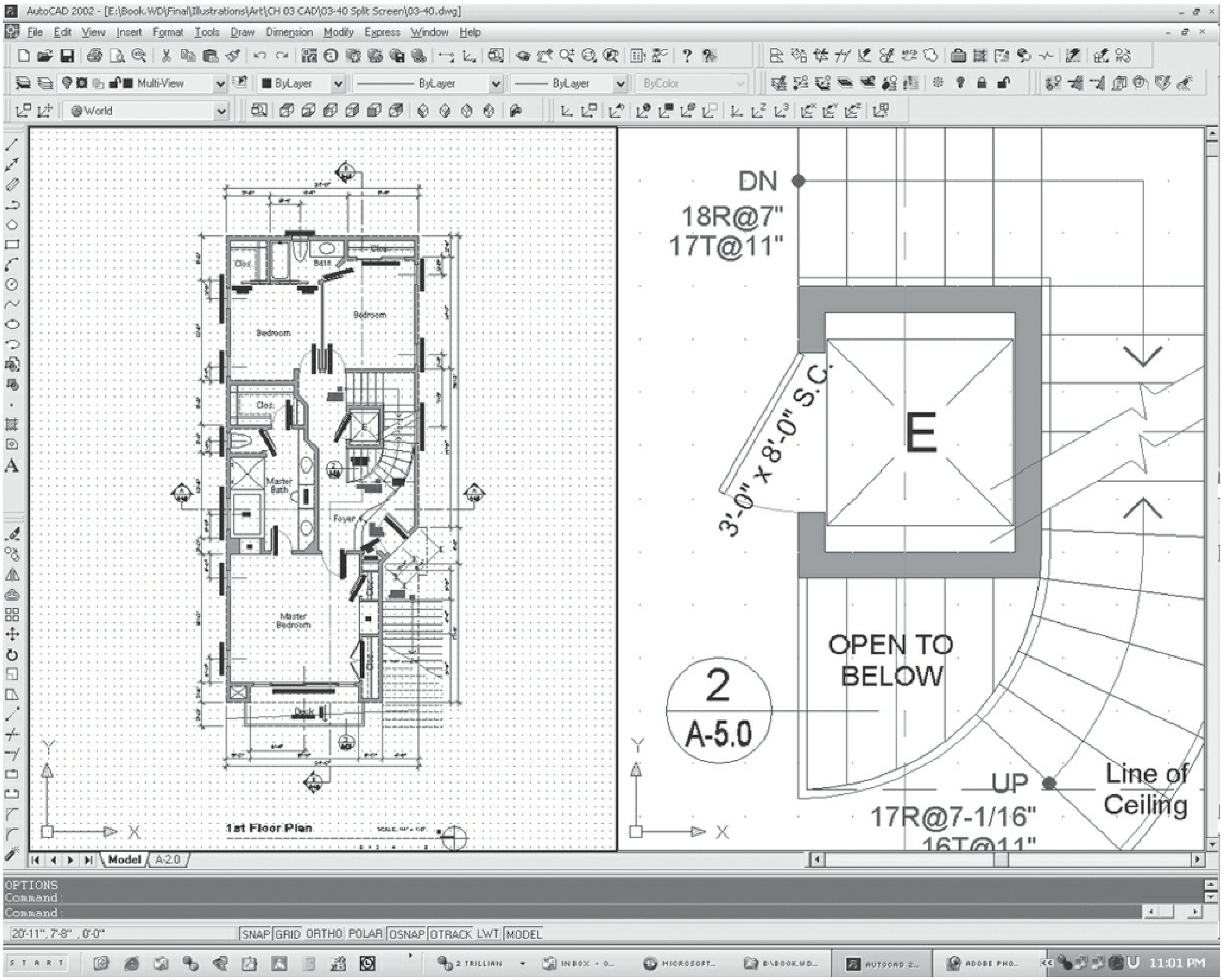


Figure 2.86 Split screen.

(Courtesy of Norman LeBeau, owner.)

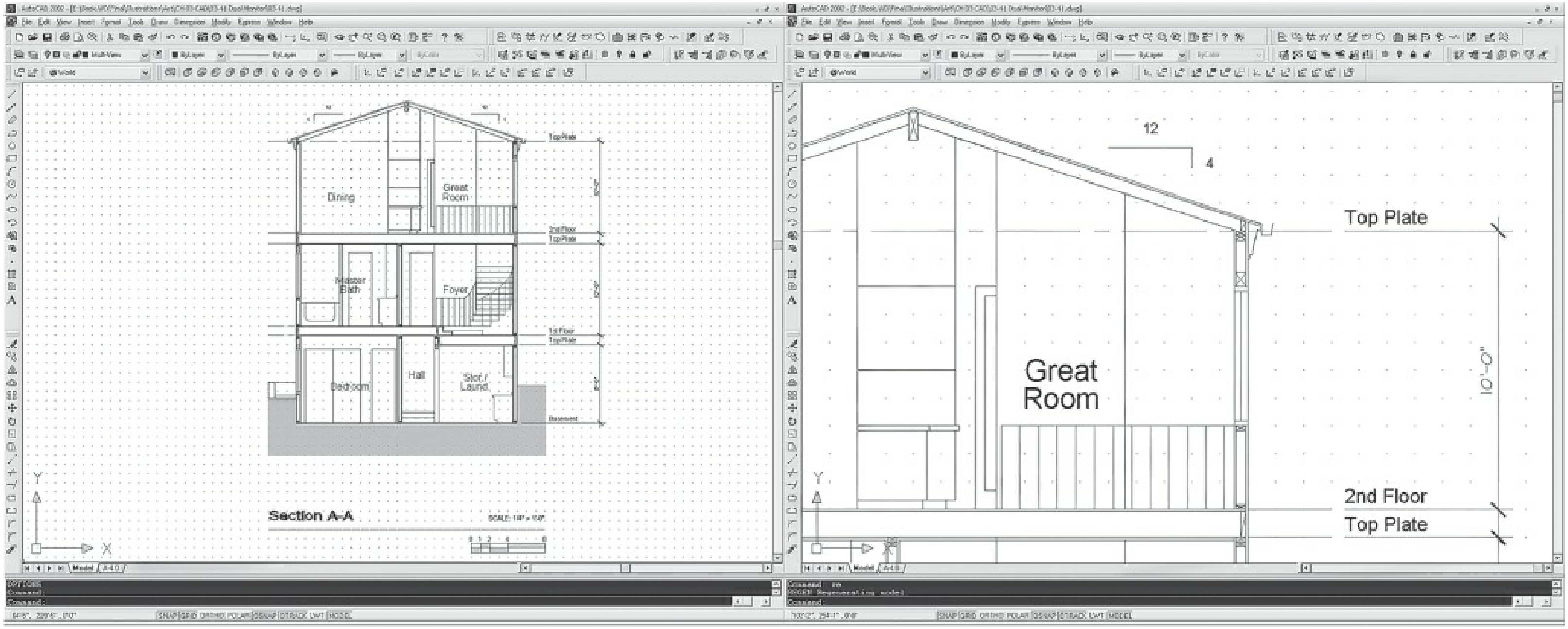


Figure 2.87 Dual screen.

The computer was made for repetitive and redundant tasks. The accuracy and speed with which a computer carries out these tasks is far superior to the abilities of even the best manual drafter.

Computers can be networked so that if many drafters are working on one project, they can communicate with each other. As one drafter changes an element of a drawing—say, a window size—the change will be reflected on the drawing of the computers that are networked (this feature is particularly valuable when XREFed drawings are changed).

The computer programs of today can perform many tasks simultaneously. As a drafter is outlining a floor plan, for example, the computer is also computing the perimeter and the square footage of this polygon.

Because the computer can draw in 3…D, any potential problems, whether in construction, installation, or other areas, can be identified before they occur.

New computer programs that are rapidly being introduced require the new breed of computer technologist to thoroughly be aware of BIM, sustainable/green architecture, and the computer engine to make this a possibility in our industry. This means that you cannot depend on any old information that you may have added but literally from scratch. This book deals with the information that the new breed of technology will need about architecture in general. Basically, you will not be able to use the information that you currently have about computers because that information will become a hindrance in what you need to know presently.

Future of CAD

Even in the development stage, the approach to working drawings has significantly changed within the past two decades. Because of the new programs, architecture requires you to know more about the finished product than about the drawing methods. For

example, for the Clay Theater project and Madison Steel building, as in all other projects used in this book, our understanding and comprehension of the facts governing the design becomes more important than the technical skills for the architect and/or designer. Following are a few the new breed of architectural technicians must know.

NATIONAL CAD STANDARDS

This section is devoted to the architectural professionals and those who earned a five… year professional bachelor of architecture or master's in architecture from an accredited institution, plus those who have a working knowledge of BIM and wish to upgrade their practice in architecture.

For a number of years we have had the U.S. national CAD standards (NCS); however, an office must now subscribe to the latest NCS…V6 edition, as it now includes BIM. This inclusion of BIM is critical because it is the natural evolution of architecture in all phases: designing, construction documents, and the building of structures that will ultimately create a process missing in the past.

METRICS

Why are metrics so important for students and professionals in architecture? With this information one can work internationally. Often, we see European architects designing structures in our country, but we too have reciprocal opportunities. At any level, knowing the metrics helps broaden the scope of your employment.

There are a number of ways that one can understand metrics; however, in this section we will discuss only three. Of the three, the third is the most critical and sound way to understand metrics. Because computers are very familiar to our youth, you should take advantage of your computer skills and research metrics. The first task will be to convert feet and inches into their metric equivalents, but this should not be done when you are producing construction documents. A second way of converting and understanding how a building is proportioned is a system called *dual dimensioning,* which was very popular until the last decade. If a building is drawn metrically, dual dimensioning allows a person using the English system to understand the proportions and size the structure. We emphasize again that dual dimensioning should never be used to do construction documents. In order to design a building from scratch, the structural engineering, mechanical, and electrical systems being utilized and the design system must all be aligned into a single system. This has become urgent because of the recent introduction of BIM.

Direct Conversion of the English System to Metrics

U.S. standards to metrics conversions:

Writing Metric Numbers

- Always use decimals and a zero marker before the decimal if smaller than one.
- Do not use periods with metric units' symbols.
- Use spaces instead of commas to separate blocks of three digits in numbers with more than four digits.
- When converting U.S. units of measure to metric units, it becomes critical to understand the difference between a soft and hard conversion.
- A soft conversion is converted to exact (or nearly exact) metric equivalents. The unit equivalent of 1 inch in this format is 25.4 mm.
- A hard conversion is a new rounded rational number that is convenient to work with and remember. The unit equivalent of 1 inch in this format is 25 mm.

Visualizing Metrics

- 1 mm is approximately 1⁄25 an inch (slightly less than the thickness of a dime).
- 1 m is approximately 3 feet 3 1⁄3 inches, or 39.33 inches.
- 1 inch is longer than 25 mm.
- 4 inches are longer than 100 mm (4 inches equals 101.6 mm).
- 1 foot is 3⁄16 of an inch longer than 300 mm (12 inches = 304.8 mm).
- 4 feet are 3⁄4 of an inch longer than 1200 mm (4 feet = 1,219.2 mm; 1200 mm = 3 feet 11 1⁄4 inch).

Metric Equivalents of U.S. Standard Dimensional Fully Dressed Lumber

- For example, a 2′ × 4′ ceiling grid can be converted using the hard conversion factor. One foot is approximately 300 mm, which would convert a 2′ × 4′ ceiling grid to 600 mm × 1200 mm.
- Example: Plywood sheathing comes standard in the United States as 4′ × 8′. Using the hard conversion factor of 25 mm equal 1 inch would give us the metric conversion of 1200 mm × 2400 mm.
- Again with plywood sheathing, using the soft conversion that is 25.4 mm would equate to 1219.2 mm × 2438.4 mm. Metric sheathing is 3⁄4″ × 1 1⁄2″ narrower and shorter.

Rules for Linear Measurements

1. Use only meters, centimeters, and millimeters in building design and construction.
2. Use kilometers for long distances and micrometers for precision measurements.
3. For survey measurements, use meters and kilometers.

Rules for Area

1. The square meter is preferred.
2. Use the hectare for land and water measurements only.
3. Avoid the use of square centimeters.

Conversion factors

Length	From Inch Pound Units	To Metric Units	Factor
Soft Conversions			
Mile	km	1.609	344
Yard	m	0.914	4
Foot	m	0.304	8
	mm	304	8
Inch	mm	25.4	
Area			
Square mile	km²	2.590	00
Acre	m²	4 046.856	
	ha (10 000 m²)	0.404 685	6
Square yard	m²	0.836 127	36
Square foot	m²	0.092 903	04
Square inch	mm²	645.16	

Using Three Translation Standards

Because metrics have only recently begun to be used in the American architectural profession, we are not yet geared to note things metrically. Lumber, reinforcing, glass, and other materials are still ordered in the English system. Their sizes, weights, and shapes are also still described using the English…system terms.

There are three approaches to this situation. First, we can note only those things we have control over in metrics, such as the size of a room, the width of a footing, and so on, while noting 2 × 4 studs, #4 reinforcing bars, ½″ anchor bolts, and the like, according to the manufacturers' nomenclature (until they change to the metric system).

A second method is dual notation. This system requires dimensions, notes, and all call…outs to be recorded twice. For example, a 35′…6″ dimension would have the metric value of 10.820 4 written directly below it.

The third and final method is to approach everything metrically. This may not be the best way in an office going through a transition, but it is the best student method because you will eventually be asked to work totally in metrics.

Metrics for the Beginner—Translation I

The translation from the English system to metrics is relatively easy if you are working on the computer. If you have a 4′…8″ wall, for example, you need only to use the program that is in your computer and convert the feet and inches to a metric dimension. Please note that the computer will round off your size to a specific size, which is not exactly 4′…8″.

This is a good way for beginning students to understand the shape and size of the building when trying to comprehend the major components of the structure. This method is purely what we call a "guesstimation," and should never be used for construction documents.

Using computers during the metrification process is becoming relatively difficult, as computers incorporate BIM by way of such vehicles as Revit because their programmers are trained in engineering rather than architecture. Initially, the symbols and conventions remain the same. Line weights, color, and layers also remain the same. In other words, the language remains the same. The only difference is the scale (ruler) used to make the changes. Thus, the unit of measurement changes. Structures do not change size. When we change from feet and inches to metric equivalents, what is being measured does not change, only the instrument we use with which to measure. This means you deal with four things on the computer:

- The reason for the need for conversion: Is the structure being built in a foreign country or in the United States?
- Is the engineering for the structure being done in the United States or outside the United States?
- Are the materials being used in this country or the country in which the building is being built?
- How are the figures being rounded off?

English Equivalents

Here is a quick reference chart for converting linear measurements into metrics:

***Length*:**		
inches	× 2.54	= centimeters (cm)
feet	× 0.304 8	= meters (m)
yards	× 0.914 4	= meters (m)
miles	× 1.609 34	= kilometers (km)

Unit Change

To convert 17′…8″, follow this procedure:

17 ft	× 0.304 8	= 5.181 6 m
8 in.	× 2.54	= 20.32 cm

In this example, conversion of feet results in meters, and conversion of inches results in centimeters. You cannot add these quantities unless you convert them to the same unit of measurement. Do this simply by moving the decimal point. In this example, if meters are desired, simply move the decimal point of the centimeter unit two units to the left: 20.32 cm are equal to .203 2 m. Thus,

17 ft	=	5.181 6 m
8 in.	=	.203 2 m
		5.384 8 m

Dual Dimensioning—Translation II

A quick way to translate a construction document you have on your computer or saved on a flash drive, CD, or network is to translate the feet and inches directly under the feet and inches, in what is known in the industry as dual dimensioning. It is believed that dual dimensioning is no longer recommended as a way of building construction documents. Look at Figure 2.88, which shows the original dimensions above the dimension line and the translation directly under the dimension lines. Again, for newcomers, we recommend that this technique be used only to try to understand the size and shape of the drawing you are researching but should never be used for construction documents for building.

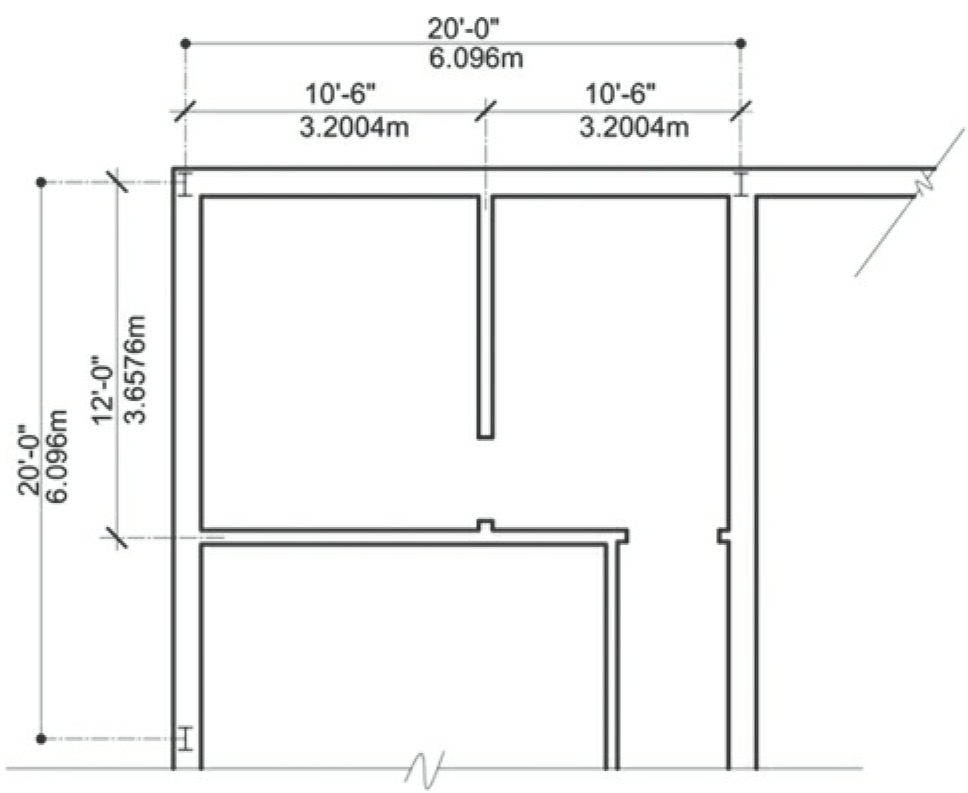


Figure 2.88 Dual dimensioning translation.

The Metric System—Translation III

A Very Special Note. If the structure is being constructed in the Orient, Europe, or any site that uses metrics, you must first contact the country and find the standard size of the wood and masonry units; the thickness of the gypsum lath, glass, or sheathing; and the diameter for its steel products. If you are engineering the structure, you must extrapolate the various sizes of its masonry units. In other words, you must understand its language in the building industry so your design can be built with the proper aesthetics and structural stability. Noting will also be changed. Wood studs, for example, will use a different name because of the language and will be called something else.

To truly understand metrics, their use, and the system they follows, a beginner must treat metrics as if he or she were learning a brand…new language. You must understand the vocabulary, the method that is used, the standard drawing sheet sizes and the translation block, the various sizes of products, and so on.

A meter comprises 10 decimeters, which in turn each comprise 10 centimeters. The smallest unit of conversion is the millimeter. Ten meters make a decameter; 10 times that is a hectometer; and 10 times that is a kilometer. The following chart shows these values:

kilometer = 1000 meters	km
*hectometer = 100 meters	hm
*decameter = 10 meters	dam
meter	m
*decimeter = 1/10 meter	dm
centimeter = 1/100 meter	cm
millimeter = 1/1000 meter	mm

* Seldom used in modern drawings.

For architectural drafting, the millimeter, centimeter, and meter are the most desirable and most commonly used units.

Notation Method

Locate the decimal point in the center of the line of numerical value rather than close to the bottom of the line. For example, 304.65 is best written as 304.65. However, the original notation is acceptable.

Commas are not used. Rather, spaces are left to denote where commas would have been. For example, 10.34674 meters would be written 10.346 74 meters, and 506,473.21 meters would be written as 506 473.21 meters. Our computers are not normally programmed to put the period in the center, so normal periods are used in their place. In addition, a space is left between groups of three digits.

Abbreviations of metric units do not have special plural forms. For example, 50 centimeters is written 50 cm, *not* 50 cms. Note also the space between the number and the letters. It should read 50, space, abbreviation for centimeters: 50 cm.

Once a standard such as “all measurements shall be in meters” is established for a set of drawings, it need not be noted on each drawing. A 4 by 8 sheet of plywood should be called out not as 1.219 2 m × 2.438 4 m plywood but rather as 1.219 2 × 2.438 4 plywood. However, if a size is in a measure other than meters, this should be noted.

Actual versus Nominal

Presently, lumber uses an odd system of notation. When a piece of lumber is drawn, it is drafted to its actual size (net size). In the notes describing this particular piece of wood, it is called out in its nominal size (call…out size). For example, a 2 × 4 piece of wood is drawn at 1½″ × 3½″, but on the note pointing to this piece, it is still called a 2 × 4.

Therefore, when converting to metric, the 1½″ × 3½″ size must be converted and drawn to the actual size. There is no set procedure for the call…out. Some drawings convert the 2 × 4 size metrically and note this piece of wood with the 1½″ × 3½″ size converted. A sample note might read as follows:

.0381 × .0889 (net) STUD

Dimension Notes and Call…outs

If, for example, we are dealing with a #4 rebar (which is a steel reinforcing bar ½″ in size) and the manufacturer has not changed to metrics, we must convert the ½″ by multiplying ½″ × 2.54 and note the rebar as:

1.27 cm rebar

or

0.127 rebar

The second step requires “rounding off.” See Figure 2.89. In this figure, the scale on the top is an enlarged one that you are accustomed to seeing. The scale directly below is in the same enlarged proportion but in metric units. The numbers in this scale are in centimeters. Notice that 2.54 centimeters equal an inch. Notice also that 1 centimeter is less than ½ inch. Initially, this is a hard proportion to relate to for anyone making the transition. Also note that half a centimeter (0.5 cm) is smaller than 1⁄4 inch and that one millimeter (one…tenth of a centimeter) is less than 1⁄16 of an inch.

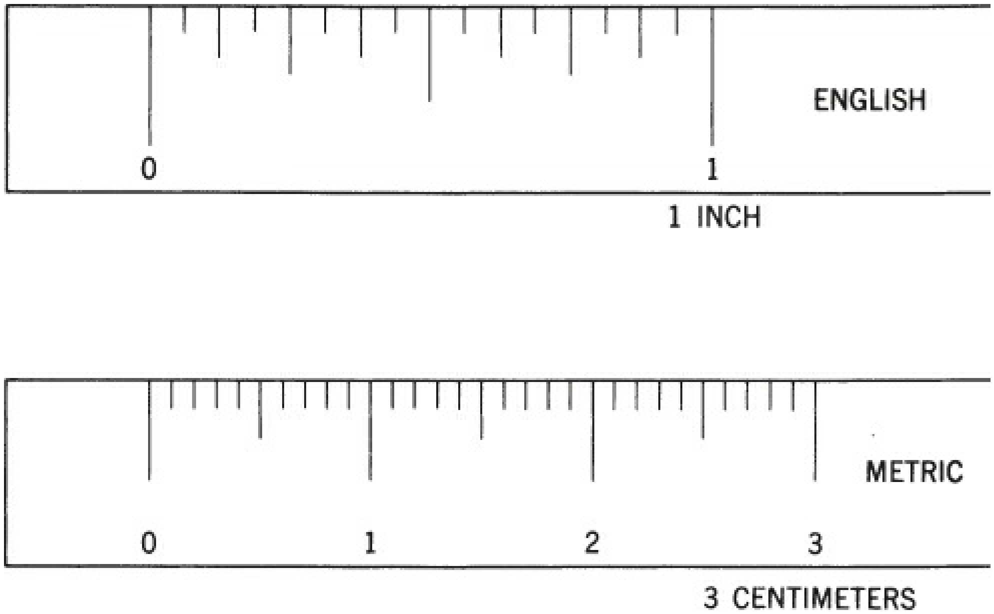


Figure 2.89 Comparison of English and metric scales.

Now compare this knowledge with an actual number. Assume that you wish to dig a trench 12 inches wide for a footing.

$$12 \text{ inches} = (12 \times 2.54) = 30.48 \text{ cm}$$

Hence, there are 30+ units less than ½ inch in size that we can measure. The .4 is less than 3⁄16″, which is very difficult to measure and impossible for a worker to deal with on the job. This is the point at which we should begin to round off.

The final number (0.08) is even worse. It amounts to just a little more than 1⁄32 of an inch—a measurement that a draftsperson would have difficulty even reading on the scale and that the person digging the trench would have to ignore. The final rounded…off value should be 31.0 cm or 0.31. This trench is about 3⁄16 of an inch wider than the desired 12 inches but is something the people out in the field can measure with their metric scales.

The third conversion step requires judgment about whether to increase or decrease. Certain measurements must be increased in the rounding…off process; the trench discussed previously is a good example. If we round this number off to 30.0 cm or 0.30, the measurement is less than 12 inches. If the 12…inch requirement had been imposed by the local code, you would have thus violated the code. Had it been set at 12 inches for structural reasons, the building could be deemed unsafe. Another example is a planned opening for a piece of equipment. Rounding off to the smaller number might result in the equipment not fitting.

Another kind of danger lies in *exceeding* a required maximum. For example, the note for an anchor bolt reads:

½″ × 10″; to anchor bolt embedded 7″ into concrete

6′ – 0″o.c. and 12″ from corners

The spacing of 6′…0″ on center is used to maintain a minimum number of anchor bolts

per unit of length. If we increase the distance between bolts, we exceed the required spacing, and (as stated in the note) reduce the number of bolts per unit of length below the minimum required.

The second and third steps are called **soft conversion;** that is, an English measurement is converted directly into a metric equivalent and then rounded off to a workable metric value. In contrast, in a **hard conversion,** the total approach is changed. It is not just a numerical conversion but a change of medium as well. If bricks are the medium, for example, the procedure would be to subscribe to a brick that was sized metrically and dimension accordingly.

Listed below are some of the recommended rounding…off sizes:

⅛″=3.2 mm	1¾″=44.0 mm
¼″=6.4 mm	2″=50.0 mm
⅜″=9.5 mm	2½″=63.0 mm
½″=12.7 mm	3″=75.0 mm
⅝″=16.0 mm	4″=100.0 mm
3/4″=19.0 mm	6″=150.0 mm
⅞″=22.0 mm	8″=200.0 mm
1″=25.0 mm	10″=250.0 mm
1¼″=32.0 mm	12″=300.0 mm
1½″=38.0 mm	

Zero is used to avoid error in metrics. For example, .8 is written 0.8 or 0.8.

When other conversions are needed, round off fractions to the nearest 5 mm, inches to the nearest 25 mm, and feet to the nearest 0.1 meter.

Metric Scale

The metric scale is used in the same way as the architectural scales. It reduces a drawing to a selected proportion. You can purchase scales with the following metric divisions.

1:5	1:50
1:10	1:75
1:20	1:100
1:25	1:125
1:331/3	1:200
1:40	

Although these proportions may not make sense initially, let us take one example and see what they mean. The 1:10 scale indicates that we are taking a known measurement (a

meter) and making it 10 times smaller. See Figure 2.90. In other words, if you visualize a meter (39.37 inches) and squeeze it until it is only one…tenth of its original size, you have a 1:10 ratio scale. Everything you draw is then one…tenth of its original size.

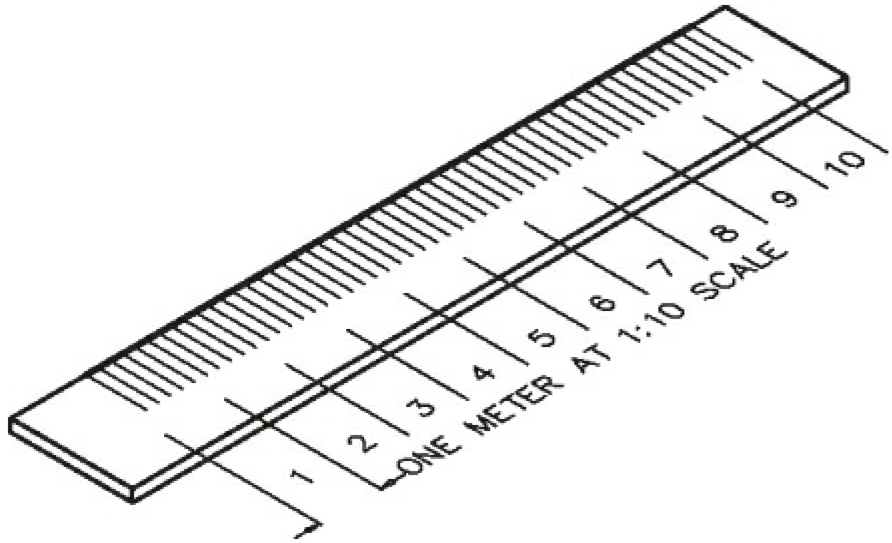


Figure 2.90 Pictorial of reduced metric scale.

This also applies to any other scale. A 1:50 scale means that the original meter has been reduced to one…fiftieth of its original length. Figure 2.91 shows the visual appearance of the 1:50, 1:10, 1:20, and 1:100 proportions, as they might be seen on an actual scale. Notice how the meter is to be located so that you can translate decimeters and centimeters. To measure 12 inches or 30.48 cm (0.3048 m) on a 1:10 scale, see Figure 2.92.

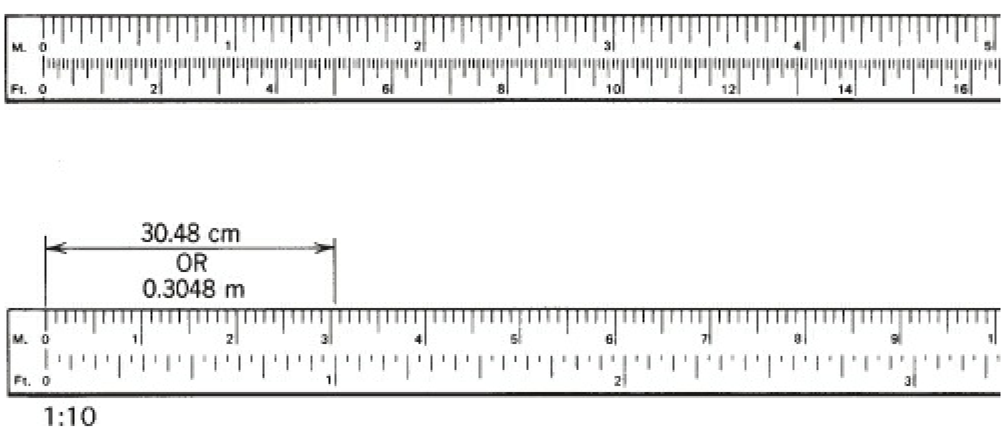
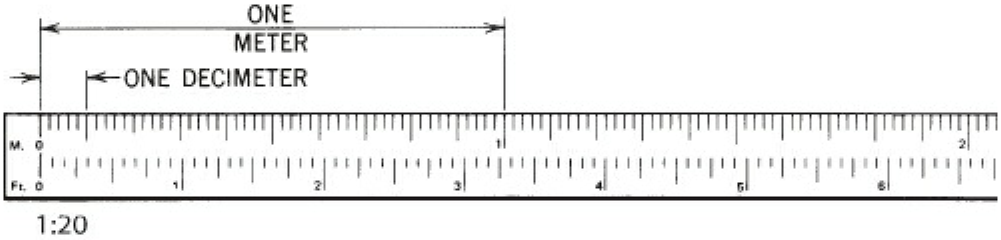


Figure 2.91 How to read an actual scale—1:20 and 1:100.



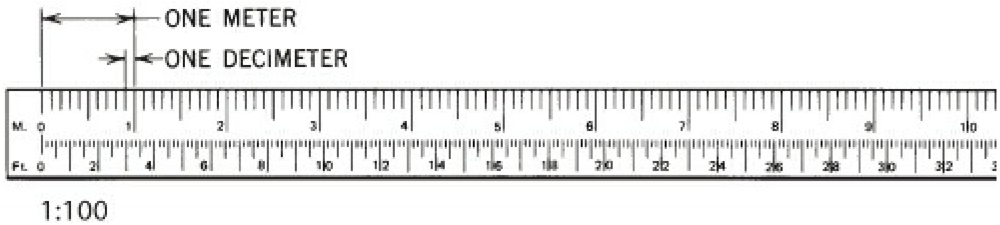


Figure 2.92 One foot equivalent in metric.

If you find it difficult to transfer a drawing scaled in inches and feet to a metric drawing, the following should help:

1:10 is approximately 1″ = 1′…0″ (1:12)

1:20 is approximately ½″ = 1′…0″ (1:24)

1:50 is approximately 1⁄4″ = 1′…0″ (1:48)

1:100 is approximately ⅛″ = 1′…0″ (1:96)

Of the four scales listed, the 1:50 and 1:100 come closest to being exact conversions.

Drawing Sheet Size

When the total conversion to metrics takes place, the change will affect not only the drawing but also the sheet size of the drawing paper. Some suggested sizes are shown in the chart below, but if the drawings are to be done in another country, the designer or the employee responsible for sheet size should check the specific country or any paper producer and find out what their sizes are. Listed are some of the typical sizes used internationally. They are expressed in millimeters (mm).

841 × 1189	105 × 148
594 × 841	74 × 105
420 × 594	52 × 74
297 × 420	37 × 52
210 × 297	26 × 37
148 × 210	

A spot check of the various paper companies that sell reproduction paper as well as drawing paper shows that metrically sized paper is already being used for overseas work.

Possible Sizes

Because the various manufacturers have not converted to a uniform size, it is difficult to predict the final evolution of the various building materials. The following lists contain suggested sizes use in a few of the European countries. These sizes should never be used in engineering or for construction documents without validation.

Wood (in mm)

38 × 75	44 × 75	50 × 75	63 × 150
38 × 100	44 × 100	50 × 100	63 × 175
38 × 150	44 × 150	50 × 125	63 × 200
38 × 175	44 × 175	50 × 150	63 × 225
38 × 200	44 × 200	50 × 175	
38 × 225	44 × 225	50 × 200	75 × 200
		50 × 300	75 × 300

Brick (in mm)

300 × 100 × 100	200 × 100 × 100
200 × 100 × 75	200 × 200 × 100

Gypsum Lath (in mm)

9 × 5	12 × 7 or 12 × 00

Miscellaneous

12 mm diameter for rebar

3 mm for sheet glass

25 mm for sheathing

Modules

As indicated in Figure 2.93, the standard **module** in metrics is 100 mm. Groups of this standard 100…mm module are called a **multi_module**. When you select the multi… module, you should consider quantities such as 600 mm, 800 mm, 1200 mm, 1800 mm, and 2400 mm. All of these numbers are divisible in a way that allows you flexibility. For example, the 600…mm multi…module is divisible by 2, 3, 4, and 5. The result of this division gives numbers such as 200, 300, 120, and 150. All of these are sizes in which building materials may be available. This is especially true of masonry units. Most of the sizes listed in the “Possible Sizes” section work evenly into a 600…mm module. See Figure 2.94.

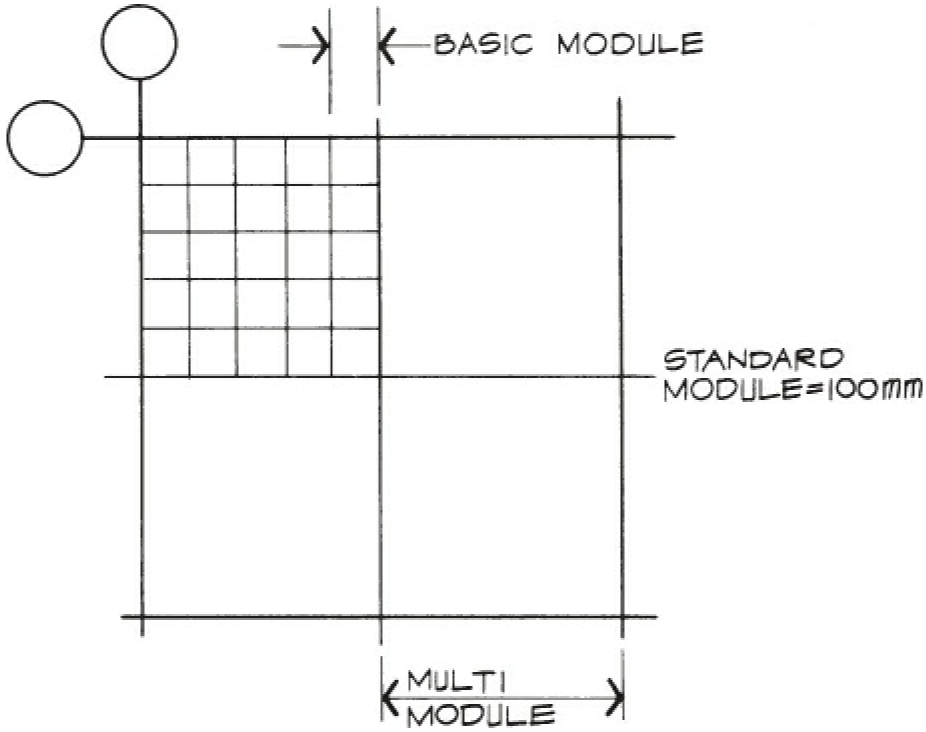


Figure 2.93 Standard module.

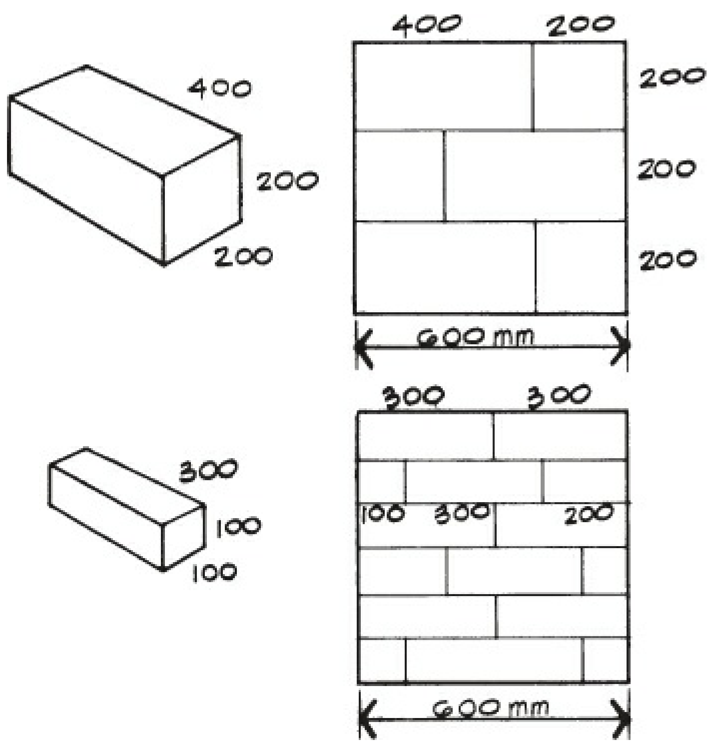


Figure 2.94 Brick and block dimensions.

Examples of Wood Floor Foundation Plan

For ease of understanding, the numbers will change, but to help you comprehend, notes will use English names for each of the components.

A sample of a foundation plan, drawn and labeled in metrics, is shown on Figure 2.95. To simplify the drawing and noting, only the dimensions and the scale found underneath the title have been changed. The notes and written information are in English, of course, but would have to be done in the language of the country in which the drawing would be

used. The structural engineering would also be adapted to specific country, as well as the sizes of the lumber, the species of wood they would use, and so on.

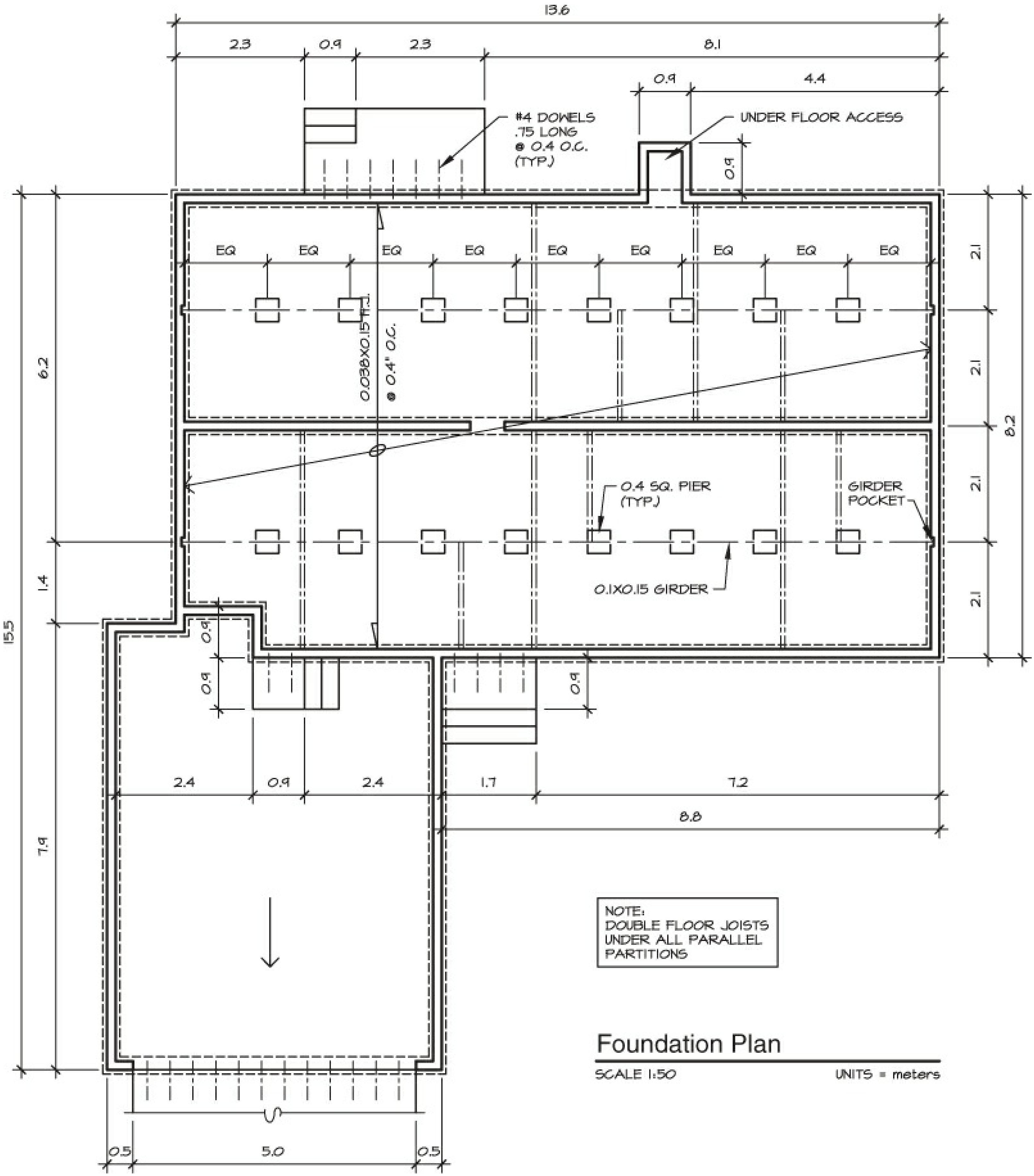


Figure 2.95 Metric foundation plan.

Desired drawings are often drawn freehand by the office manager, then translated by the

CAD drafter. In the case of a foundation plan, the office manager or structural engineer can decide the number of piers, size of girder, and location of access openings, to mention just a few of the items that must be sized and spaced. Figures 2.96 and 2.97 show diagrams of desired foundation plans.

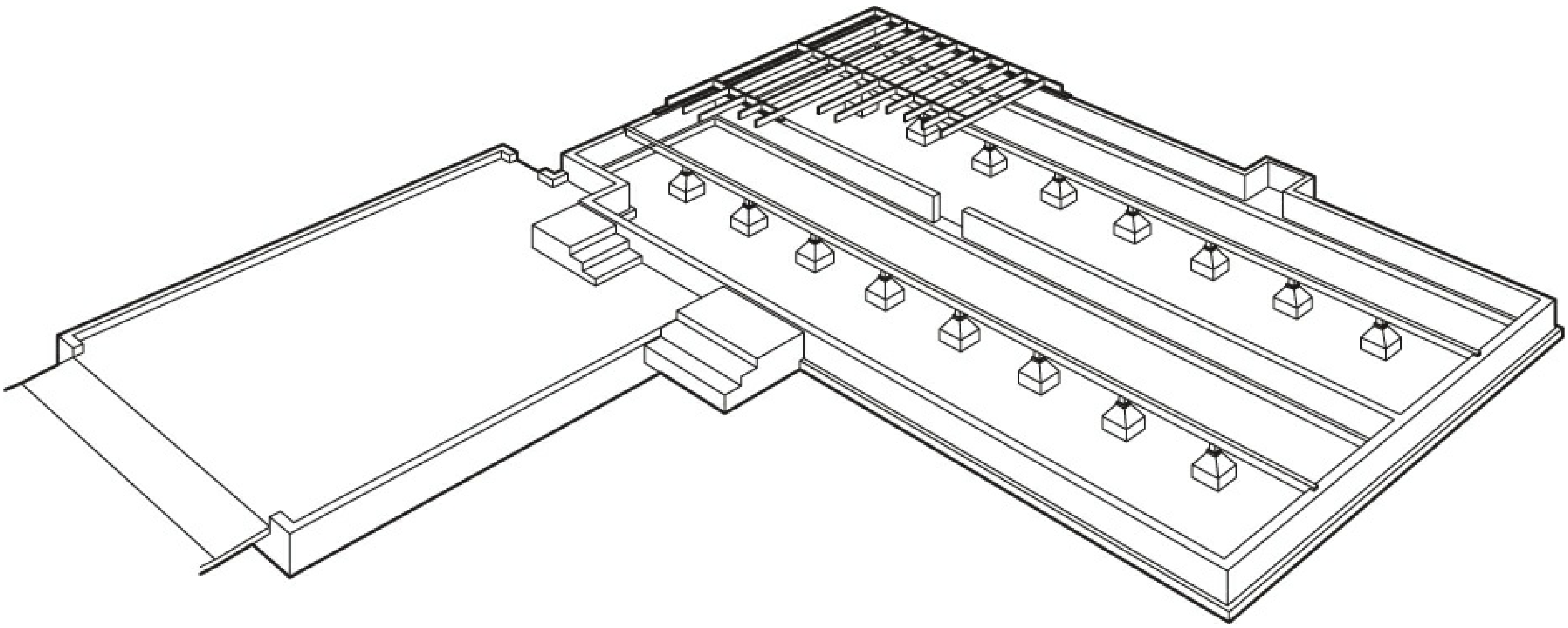


Figure 2.96 Wood floor system.

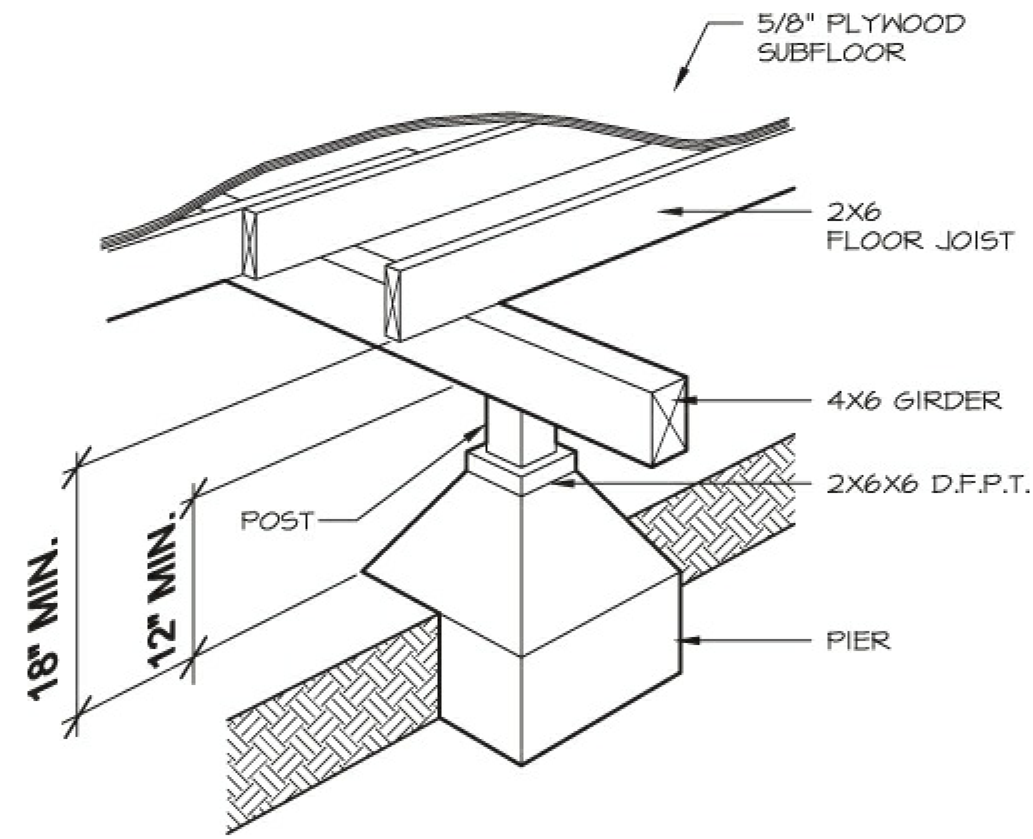


Figure 2.97 Pier and girder.

CONCLUSION

Throughout this chapter, we have tried to refrain from discussing how to use a computer

or the commands used for a specific function. Rather, we have deliberately shown the process by which a set of drawings is produced. Certainly, techniques have changed, moving from manual drafting to computer…generated drafting or use of CAD programs, but the process of building construction has not changed. The changes in the process of building have not resulted from use of the computer or the method of drawing but from changes in building technology.

The impact of BIM is now beginning to be fully realized by the large offices and working its way into the smaller offices. The larger offices have the ability to redesign the various programs, such as Bentley, ArchiCAD, and Revit, and are beginning to hire their own specialists to redesign the programs and customizing to fit in their own practice by using AIA and national standards as their office datum. Earlier exposure of our associates to the national (even global) interest in green architecture and the implementation of LEED in buildings should introduce architecture to a new era.

We have already seen wireless use in our world, pay…as…you…use software, new delivery methods, virtual three…dimensional buildings that you may “walk” through, and the list goes on and on.

The profession is now involved in computer programs that are designed by other than architecturally trained individuals, which is creating havoc because the architectural industry must prepare a new breed of architecturally trained technicians who are being trained in architecture while separating themselves from the older knowledge of computer technology and being retrained in an unfamiliar context. Hopefully, our colleges and universities will understand this new context and change instruction accordingly.

Key Terms

Architectural Graphic Standards

architectural profiling

axial plane

blueprints

boundary control plane

building section

composite drafting

computer…aided drafting (CAD)

control zone

cross…referencing

cross…section

design sketches

Dimensional Reference System

dimensioning

drafting room manual

drawing exchange format (DXF)

DWF

DWG

electrical plans

eraser drafting

floor plans

foundation plans

hard conversion

head

hidden lines

horizontal control plane

import

jamb

layering

lead pointer

longitudinal section

module

multi…module

net size

neutral zone

nominal size

office procedure manual

parent drawings

paste…up drafting

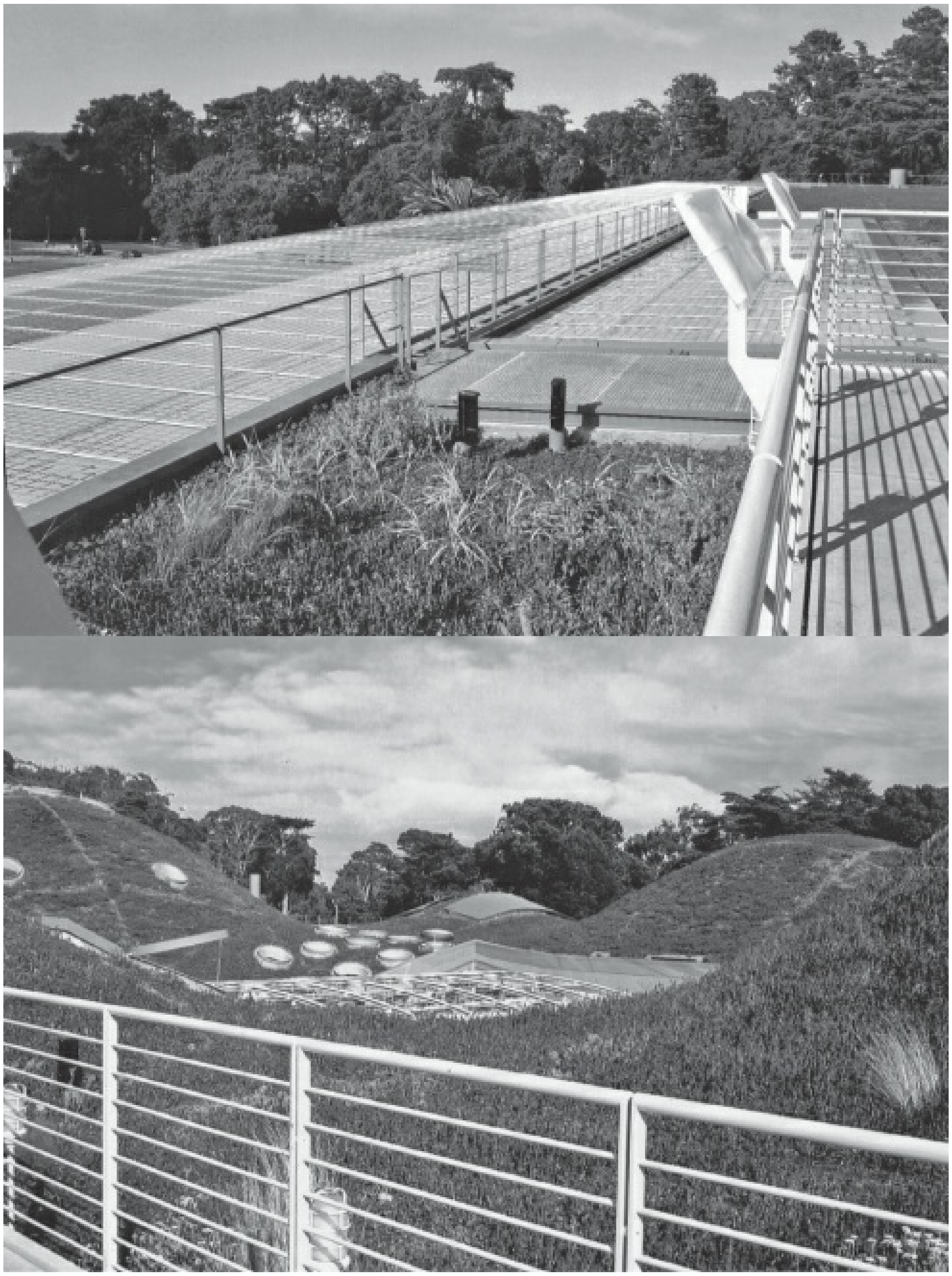
photo drafting

pilasters

pitch

planes of reference
plan
plot plan
poché
raster
restoration
scale
scan
scissors drafting
site plan
sketching
soft conversion
vector
vellum
verify
vertical control dimension
vertical control plane
viewport
virtual space
X…referencing (XREF)

Chapter 3
HUMAN CONCERNS AND BUILDING INFORMATION MODELING (BIM)



INTRODUCTION

In this chapter, we introduce building information modeling (BIM). The human concerns that are an integral part of BIM help us see a larger picture of the world.

The preceding pictures are of a building in San Francisco's Golden State Park, called the California Academy of Sciences. Designed by Renzo Piano, this 2…acre facility took 10 years to plan and 3 years to build and cost $488 million. It is both a museum and much more than a museum. The complex includes two large “houses”: one is a planetarium; the other is a 90′…diameter, four…story rain forest and coral reef where you can see live fish from above and below and birds in a natural…like habitat. Misters are used to keep the humidity similar to that found along Amazon riverbanks. There are also an African hall and a research museum. Taken altogether, the Academy sends a message about how we should care for our world and the creatures in it.

Most spectacular is the building that houses the museum. The roof is made of insulated

earth (top right photo), allowing indigenous birds and plants to live there and making the roof a 400…year…rated roof. Around the perimeter of the natural roof is a trellis with photovoltaic panels mounted on it to capture the natural and free energy from the sun (top left photo). The bottom left photograph shows the entrance; the bottom right photograph shows the roof displaced by the dome. More than 90% of the Academy's original building (concrete and sand) was reused. Its walls are sealed in denim (from recycled old jeans). The structure's basement was designed to receive natural sunlight, and in the center there is a piazza—an open space with motorized shades to control the heat and glare. Seeing this building in person makes one truly appreciate a structure that uses just about all of the green technology available today.

Governmental agencies are now beginning to require architectural firms to use CAD programs such as Bentley, VectorWorks, ArchiCAD, and Revit. Although programs other than Revit are available, large firms appear to favor Revit. Many school districts, hospitals, and large commercial projects are also requiring successful contract bidders to use BIM as the instrument for building design and construction. Thus, it behooves architects and designers to be familiar and comfortable with both BIM and Revit.

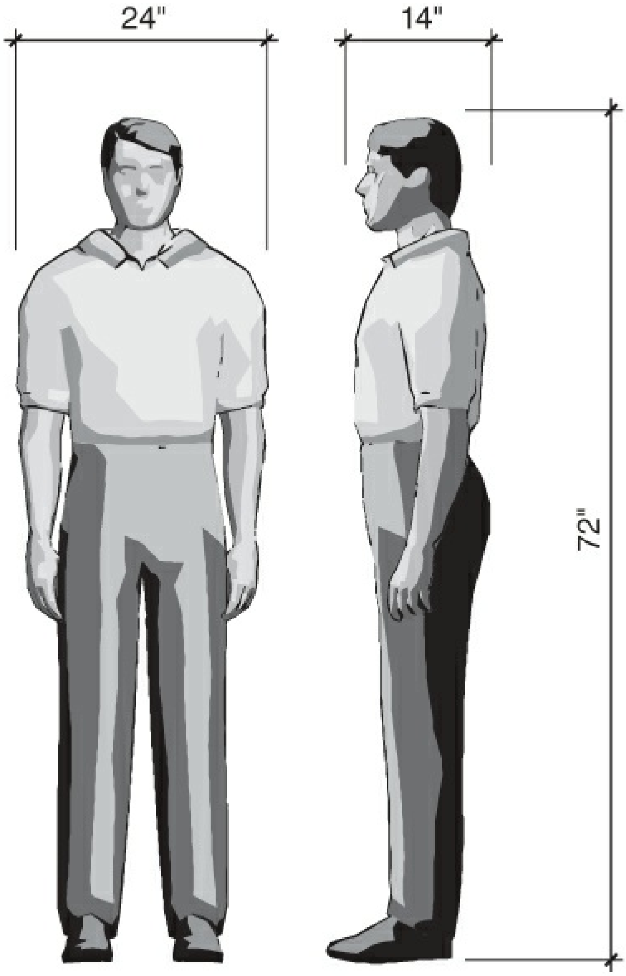
HUMAN CONSIDERATIONS

Though architects must deal with the forces that affect a structure, such as wind, rain, and seismic activity (covered in Chapter 1), they must always stay focused on the main reason the building was designed: people. It is important to understand the critical anthropometric data describing adult men and women, children, and elderly and disabled persons (**anthropometrics** is the science dealing with the measurements of the body in different groups of people). Architects can provide their clients with the best working environment by producing architecture that makes a daily task comfortable. Whether serving food at a counter, working at a computer, or selling tickets for the local philharmonic, it is important that the worker be comfortable. One should also provide comfortable settings for dining, relaxing, and, yes, even studying. Providing the best angle for viewing in a museum or a theater, or for watching a favorite television program, can contribute significantly to human comfort.

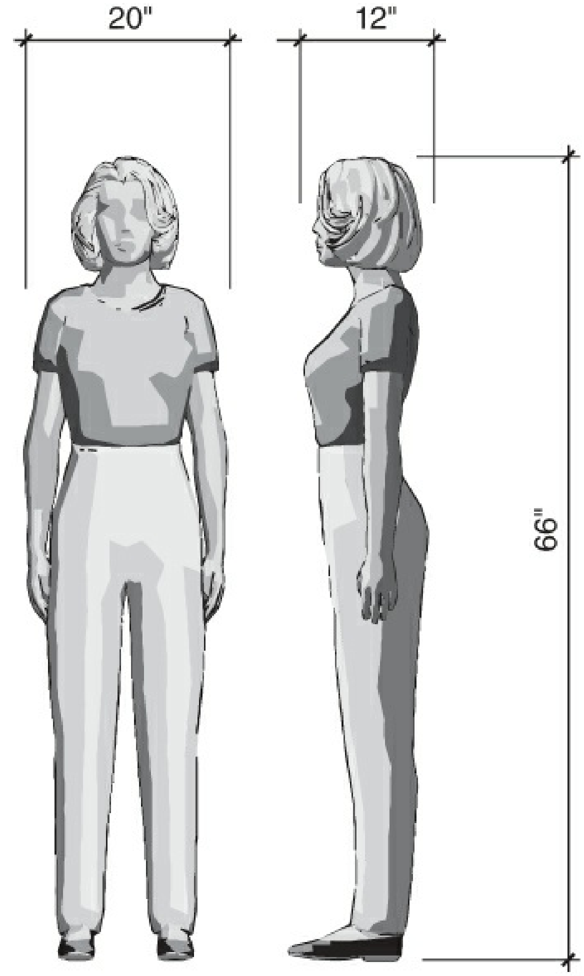
To create comfortable environments, we must first understand the limits of the human body. It is vital to study the measurements for such things as clearances under counters and desks, the maximum height a person can reach when getting an item from an upper shelf, and how far an elderly person can reach down to plug in an electrical appliance. Those who maintain public facilities must complete this type of study for many different types of users, including children and persons with special needs such as accommodation of a wheelchair. Dimensions must be considered not only in regard to the limits of individual human bodies—whether standing, sitting, lying down, climbing stairs, squatting, or even kneeling—but also in regard to such diverse conditions as clearances for shopping carts at a market, cars in parking spaces, and so on.

A sampling of these dimensions can be found in Figures 3.1, 3.2, and 3.3. For a more

comprehensive discussion of such dimensions, see the general planning and design data section of **Architectural Graphic Standards**, published by John Wiley & Sons in conjunction with the American Institute of Architects.



Male : Avg. Width, Depth, & Height



Female : Avg. Width, Depth, & Height

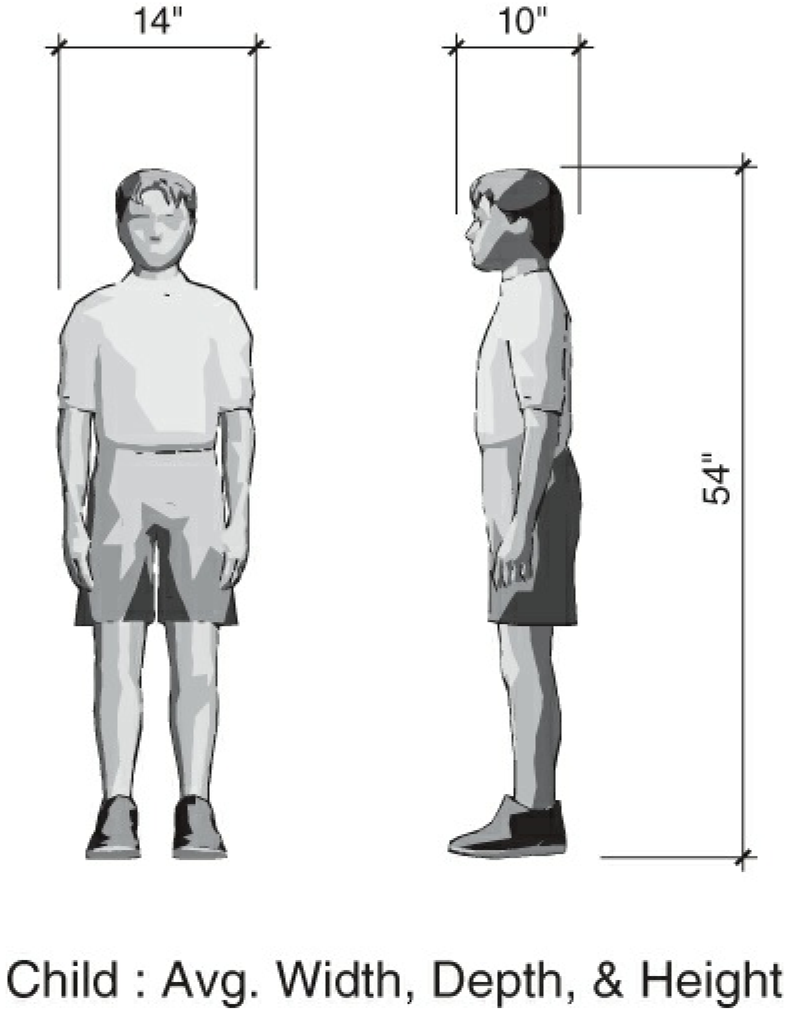
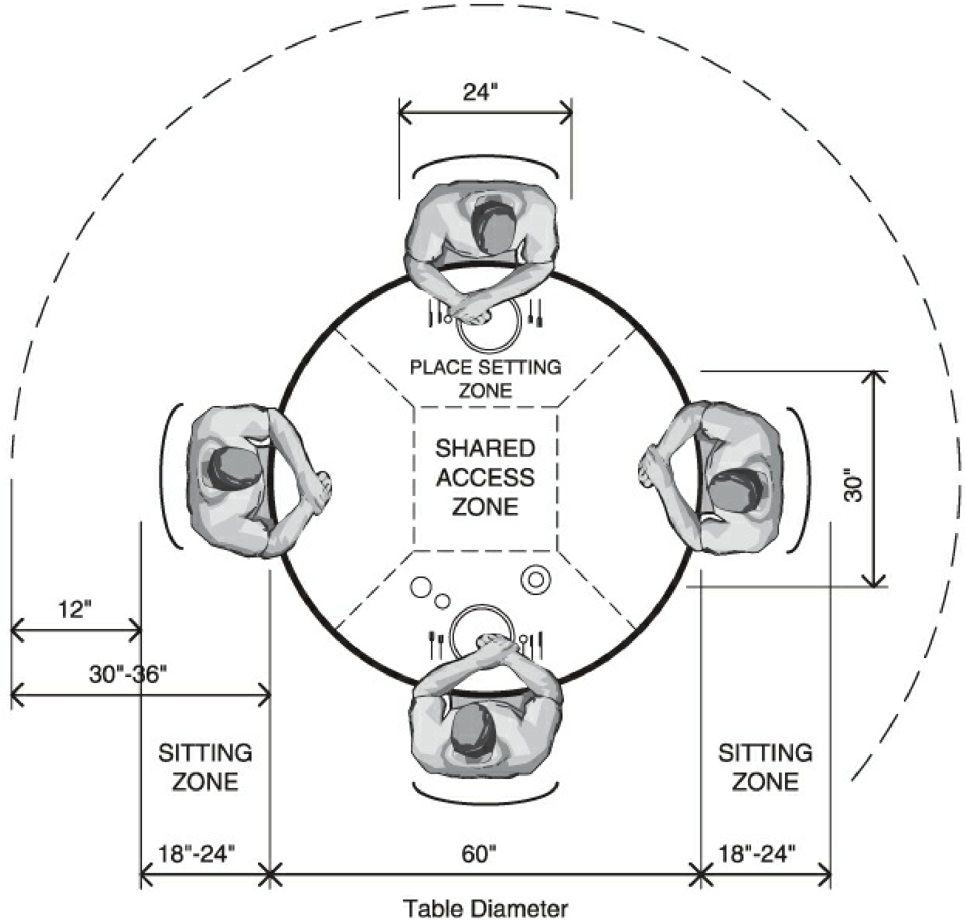
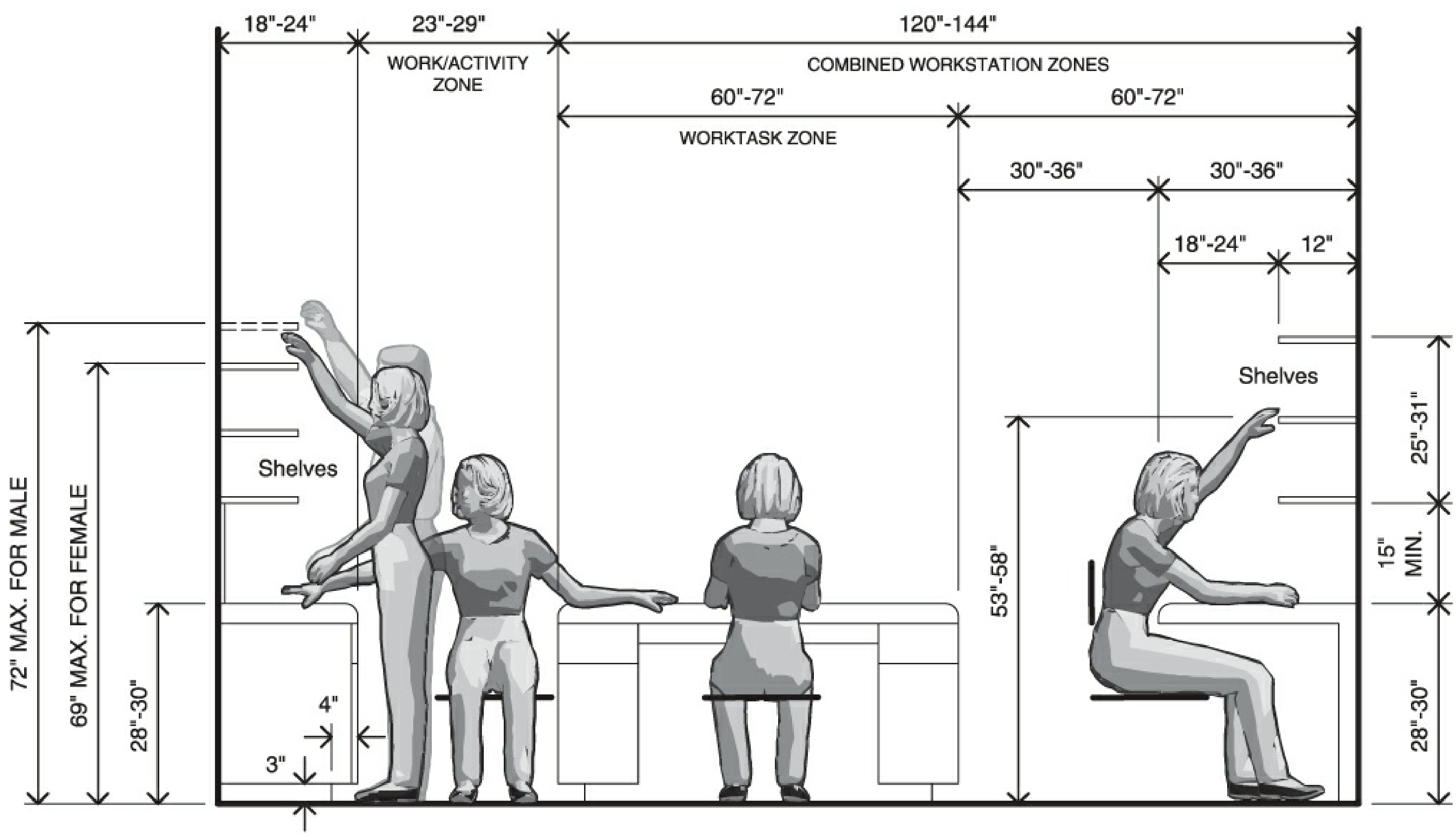


Figure 3.1 Understanding the human figure: average dimensions.

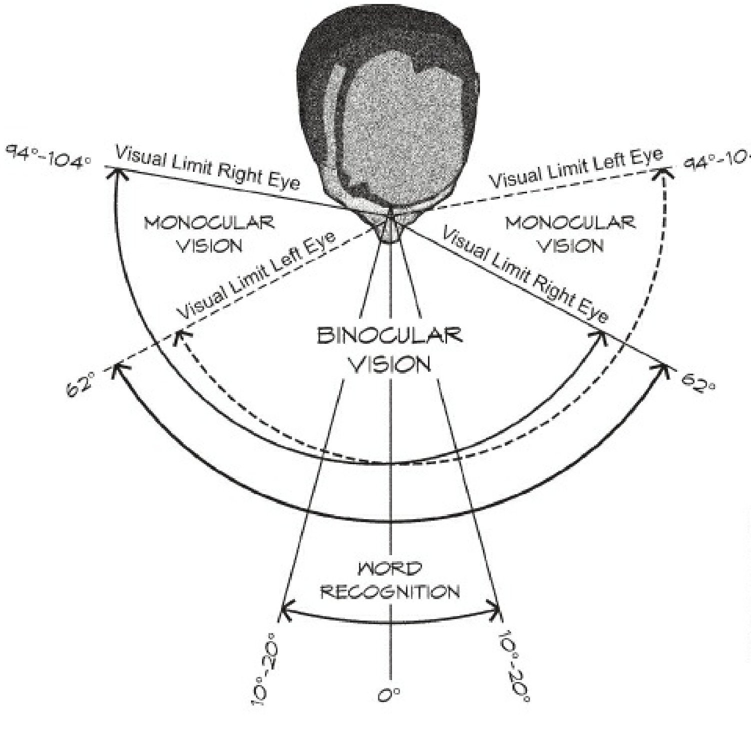


60"-Diameter Circular Table for Four / Optimum Seating

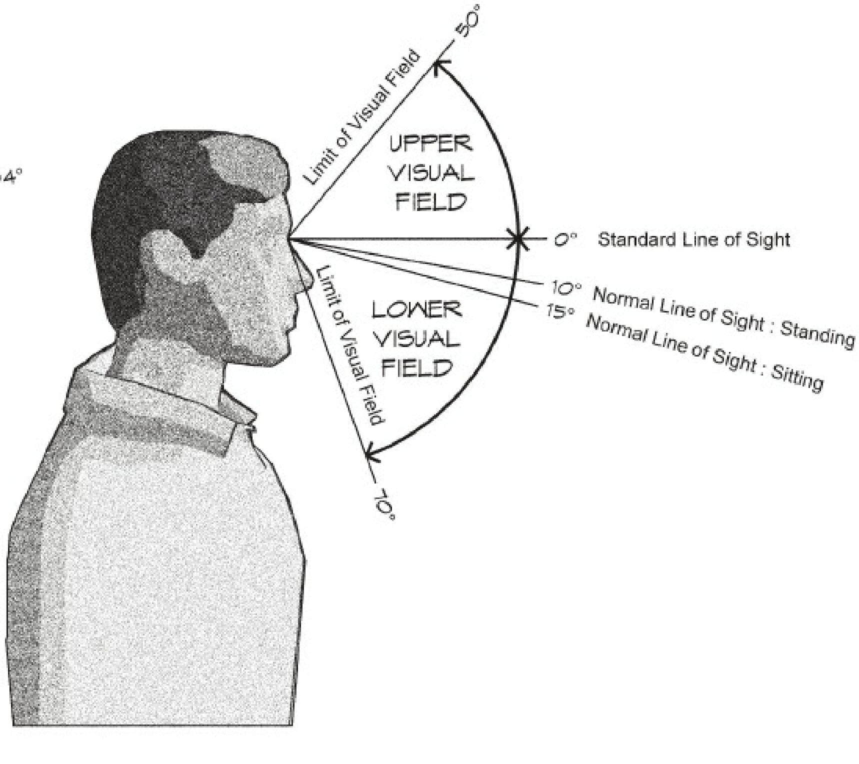


Desk and Workstation Considerations with Shelves

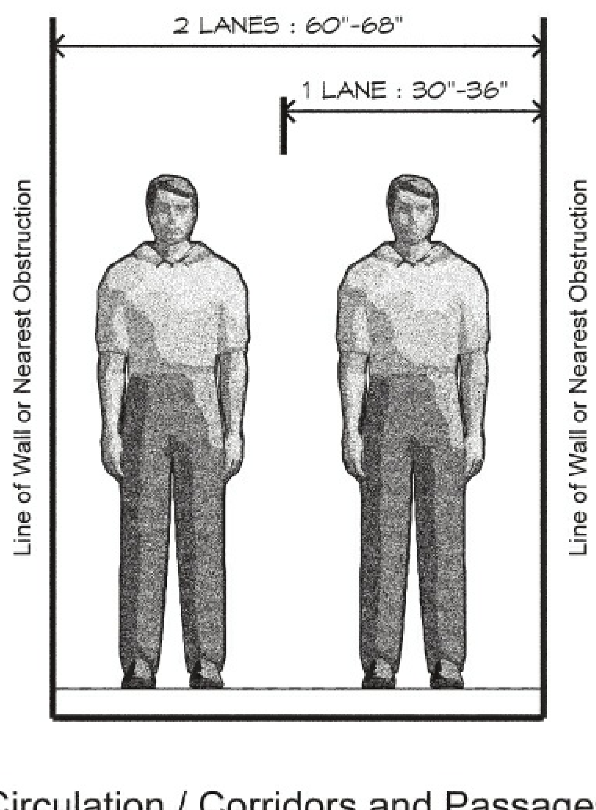
Figure 3.2 Reach.



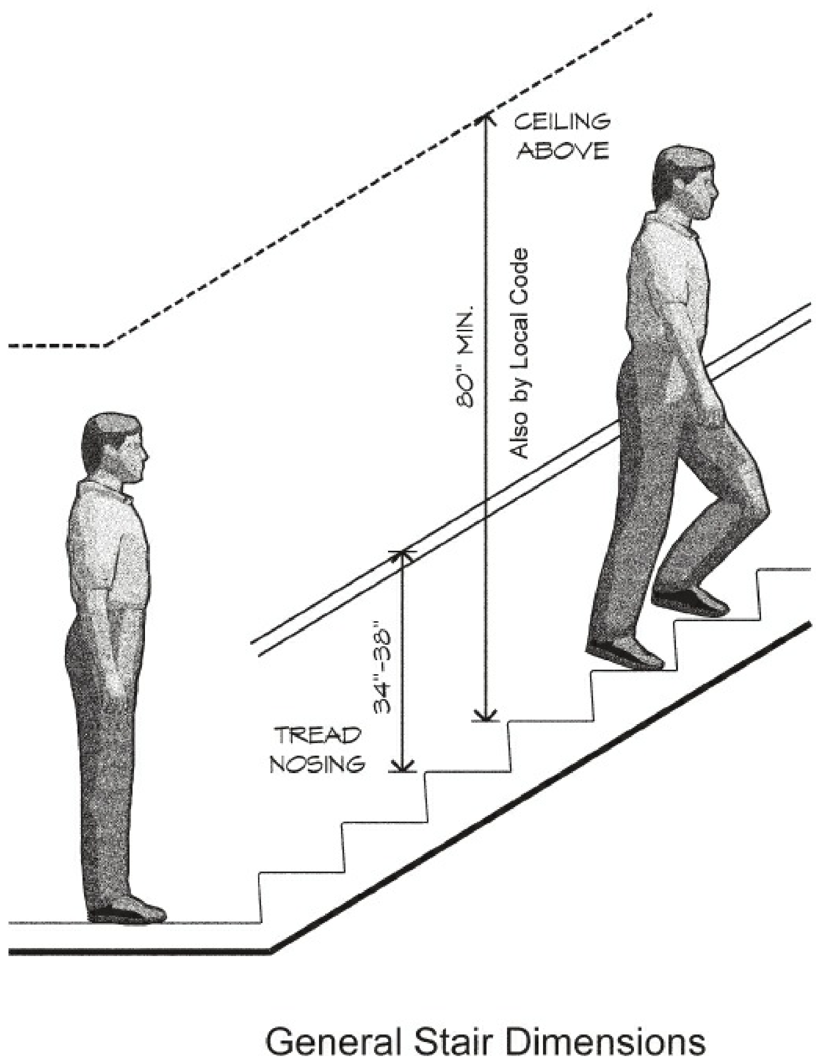
Visual Field in Horizontal Plane



Visual Field in Vertical Plane



Circulation / Corridors and Passages



General Stair Dimensions

Figure 3.3 Space relative to sight and movement.

Note that special studies are continually being performed for specific building types, such as hospitals, research centers, the service bays of automobile mechanic shops, and so on. It would be helpful to explore the Internet to study how people adjust in their leisure environments as well as in their work environments, and learn about **ergonomics**, the science of how people adapt to their environments.

AMERICANS WITH DISABILITIES ACT (ADA)

Public building accessibility is a result of legislation for the protection of persons with disabilities. The Americans with Disabilities Act, or ADA, is a civil rights law, not a building code. This law is divided into four major titles that prohibit discrimination against those who are disabled: Title I, Employment; Title II, Public Services and Transportation; Title III, Public Accommodations; and Title IV, Telecommunications. Given that the focus of this book is on building design and construction detailing, this chapter discusses Title III, Public Accommodations, and provides graphic illustrations of methods required to be used in public buildings and facilities to accommodate the needs of persons who are disabled.

The dimensions with maximums and minimums are shown only to allow readers a glimpse into the type of concerns we have as a profession. For example, Figure 3.4 shows a wheelchair going up a ramp in a curb. A designer, drafter, office manager, or architect will have to seek out the national standard and always follow that up with a check of state and local municipality regulations. Local or state regulations may be more stringent than federal guidelines and requirements.

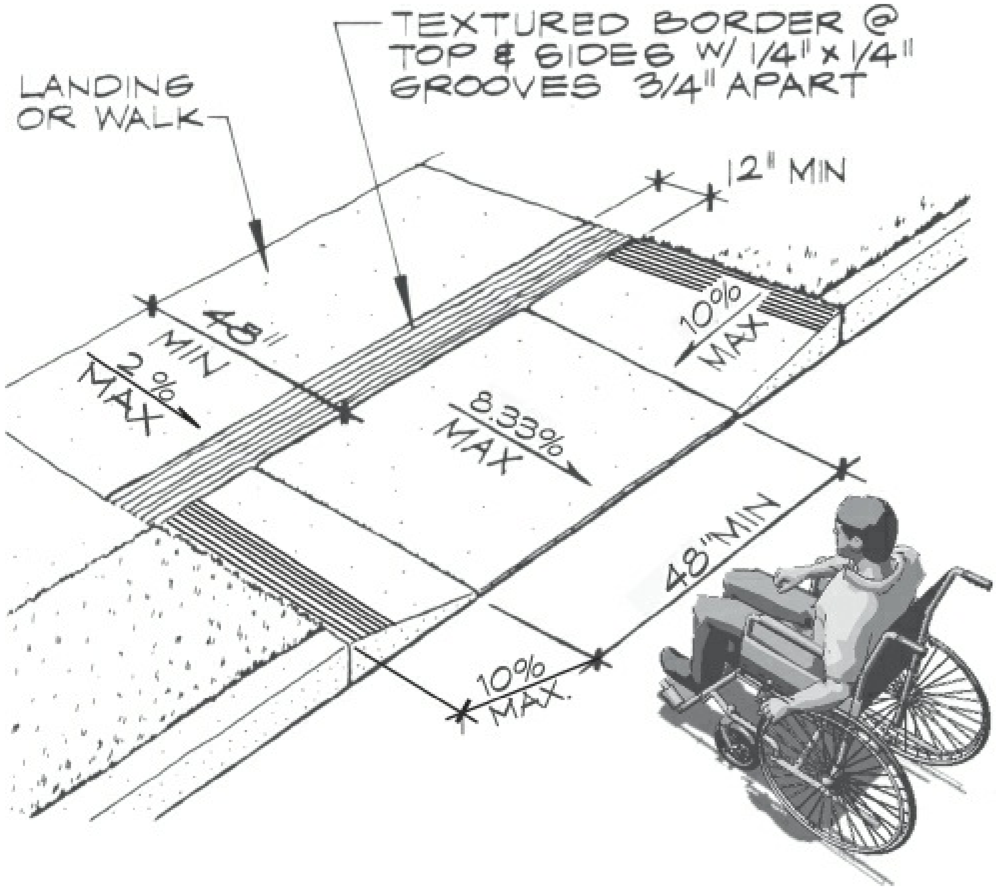


Figure 3.4 Curb ramp.

To offer greater accessibility to and better accommodations in public buildings for those with disabilities, various representatives of organizations for disabled persons have worked with federal agency officials to establish recommended standards. Requirements implementing these standards have been compiled in a list of elements that will be of concern to you as you prepare drawings and details to satisfy the various required/recommended design criteria:

1. Path of travel—exterior accessibility route to the facility
2. Accessible parking
3. Curb
4. Entrances
5. Interior access route
6. Ramps
7. Stairs
8. Elevators
9. Platform lifts
10. Doors/thresholds/handles
11. Drinking fountains
12. Toilet rooms and bathrooms

13. Water closets
14. Urinals
15. Lavatories and mirrors
16. Sinks
17. Bathtubs
18. Shower stalls
19. Grab bars
20. Tub/shower seats
21. Assembly areas
22. Storage
23. Alarms
24. Signage
25. Public telephones
26. Seating and tables
27. Automatic teller machines
28. Dressing and fitting rooms
29. Register counters
30. Floor materials/finishes
31. Electrical fixture heights

There are also requirements and recommendations for special applications in the following types of buildings:

Restaurants and cafeterias

Medical care facilities

Business and mercantile facilities

Libraries

Transient lodging facilities

Parking Stalls and Curb Ramps

For specific buildings, the required number of parking spaces for those with disabilities is determined by the total number of spaces provided for that facility. This determination is based on ratios of the cars to be accommodated. An example of ratios for disabled parking may be 4 disabled spaces per 80 total parking spaces. See Figure 3.5. Note that there are provisions for a marked access aisle, a curb ramp, a disabled/handicapped parking sign,

and a parking‑surface disabled symbol. Figure 3.6 depicts separately the freestanding disabled sign and the parking‑surface disabled symbol. In most municipalities, a large fine is imposed on nondisabled persons who use these parking spaces.

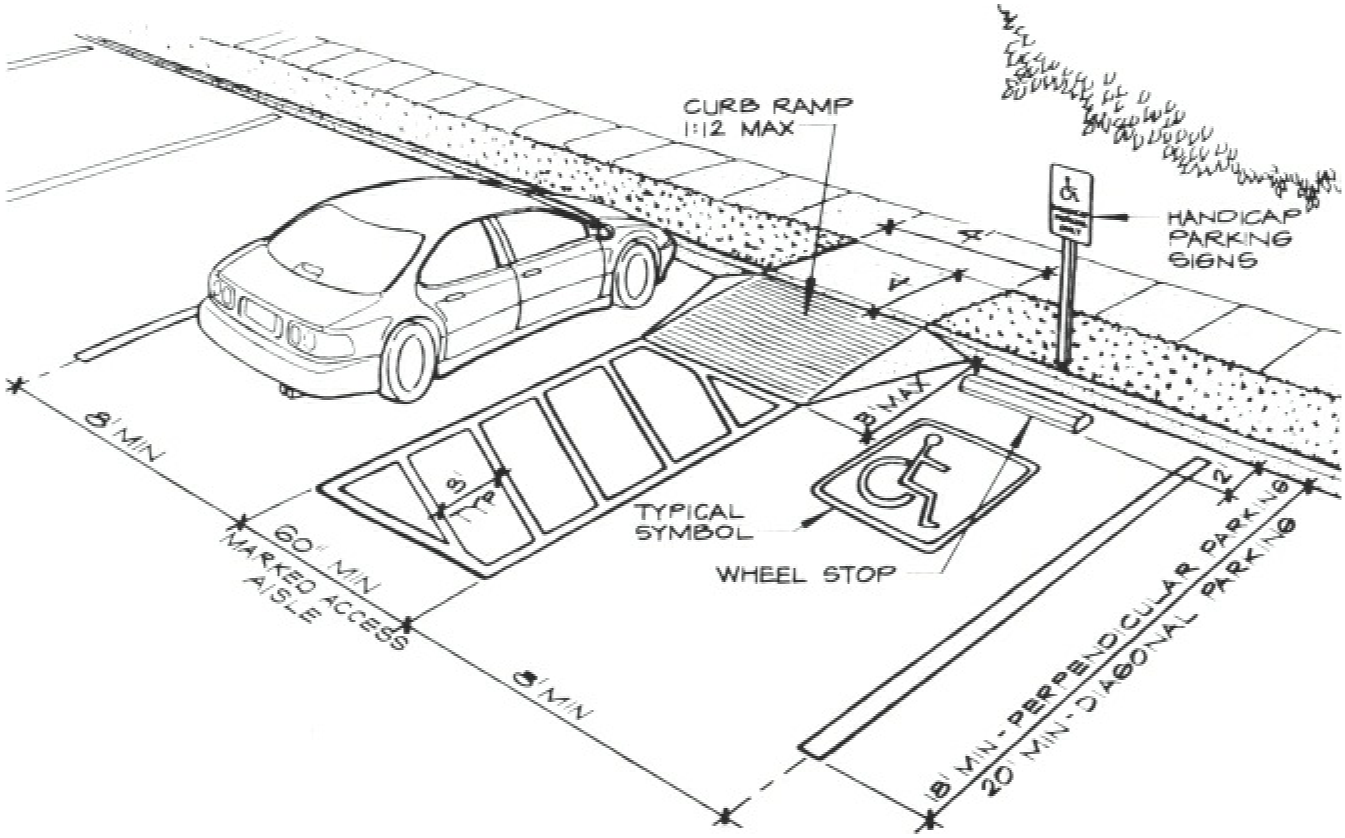


Figure 3.5 Parking spaces.

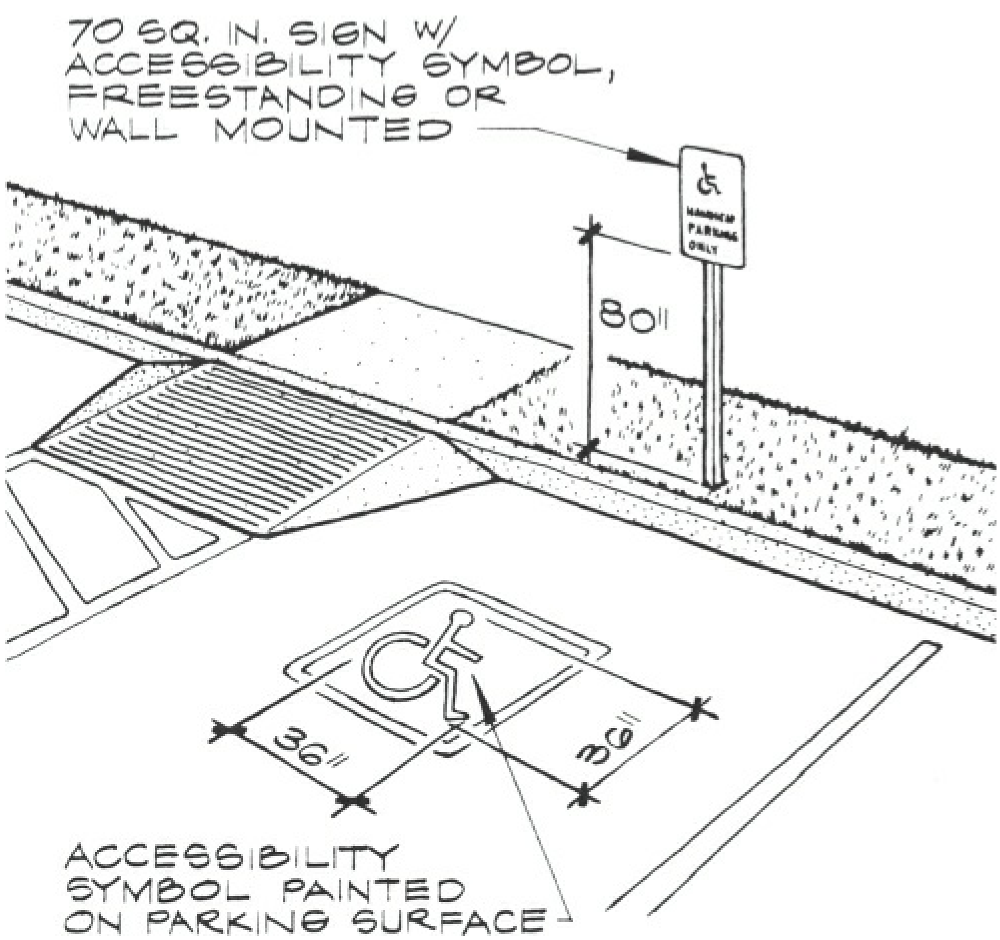


Figure 3.6 Parking sign and symbol.

Ramps. Another way of providing exterior accessibility to a facility is through the use of ramps. Figure 3.4 showed a curb ramp detail—one example of providing an accessible exterior route of travel to a specific facility. Ramps have proven to be a desirable method of enhancing accessibility when there are grade changes in the path of travel to a building. Figure 3.7 illustrates an example of an acceptable ramp with various changes in levels. Handrails are required on both sides of a ramp if the rise exceeds 6 inches or the horizontal projection exceeds 72 inches. If handrails are required, they will have to be drawn and detailed in accordance with the applicable requirements. Figure 3.8 depicts handrail requirements for the ramp shown in Figure 3.7.

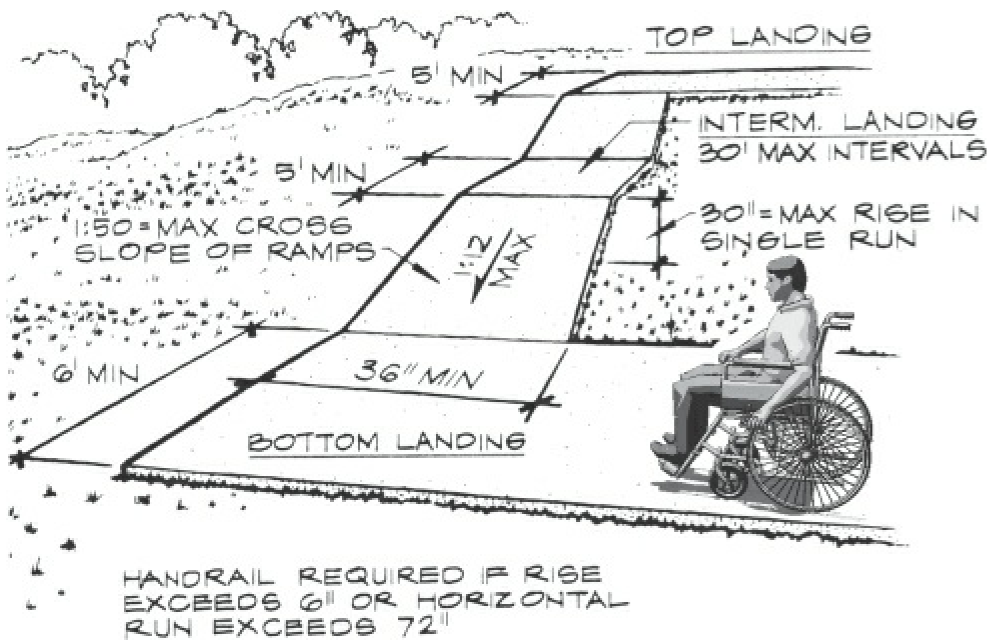


Figure 3.7 Ramp.

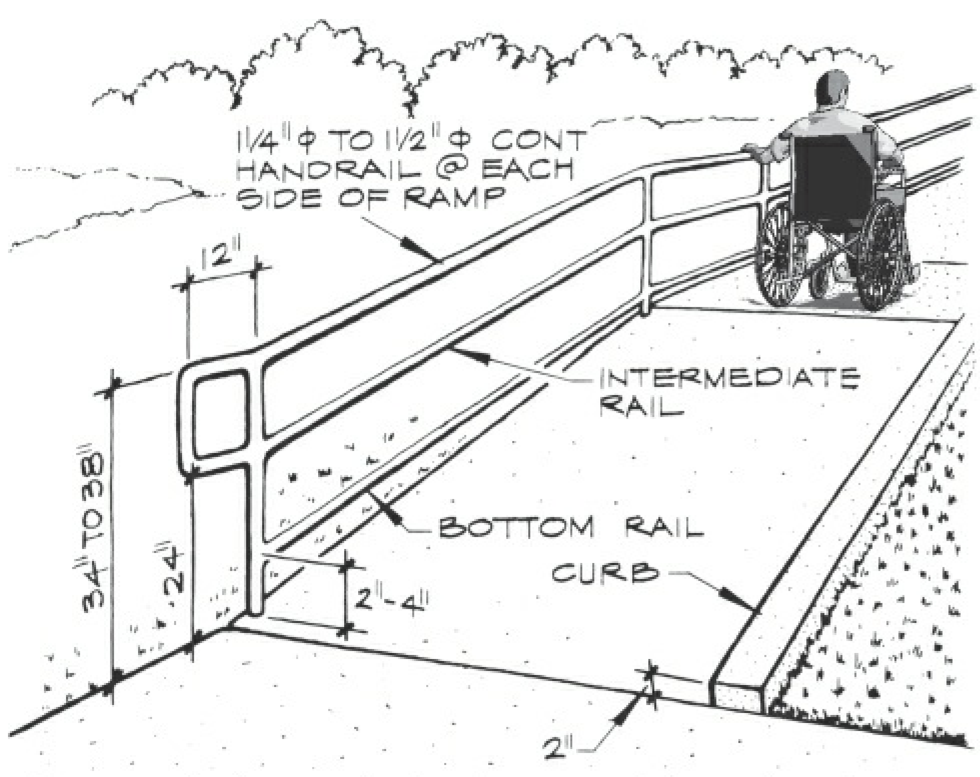


Figure 3.8 Ramp handrail.

Wheelchair Space Requirements

In cases where there are no specific rules for a particular planning situation, it is prudent for the architect or designer to be aware of the space needed for maneuverability by someone using a wheelchair. Figures 3.9 through 3.13 give some examples of floor space areas and reaching dimensions that are desirable for those who function from a wheelchair.

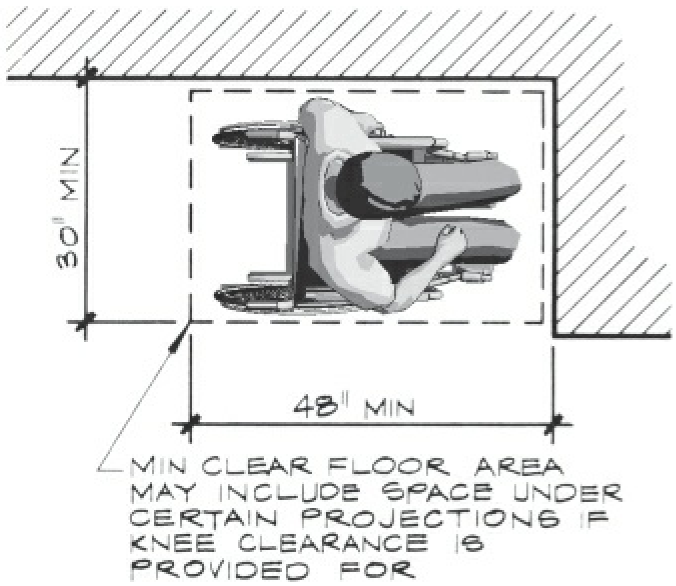


Figure 3.9 Wheelchair space requirements.

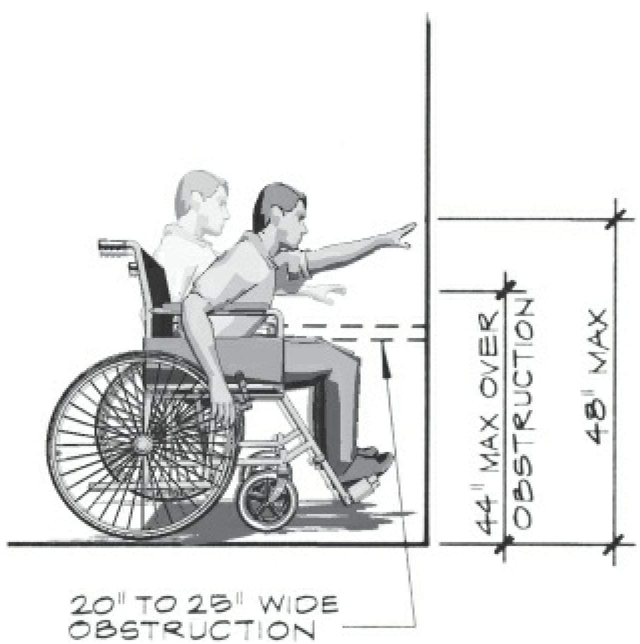


Figure 3.10 Wheelchair space requirements.

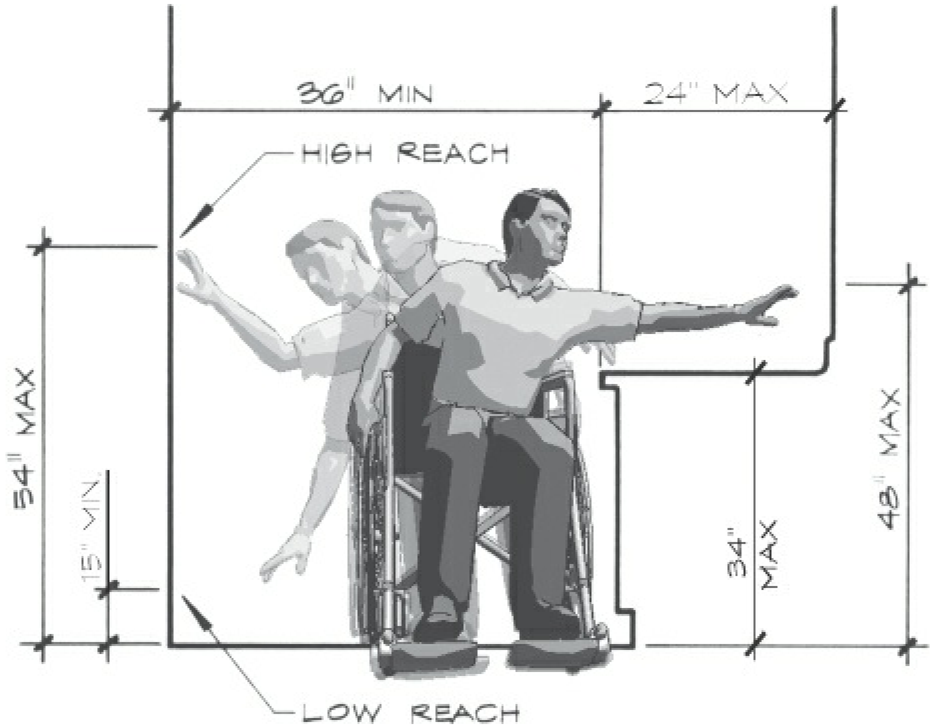


Figure 3.11 Wheelchair space requirements.

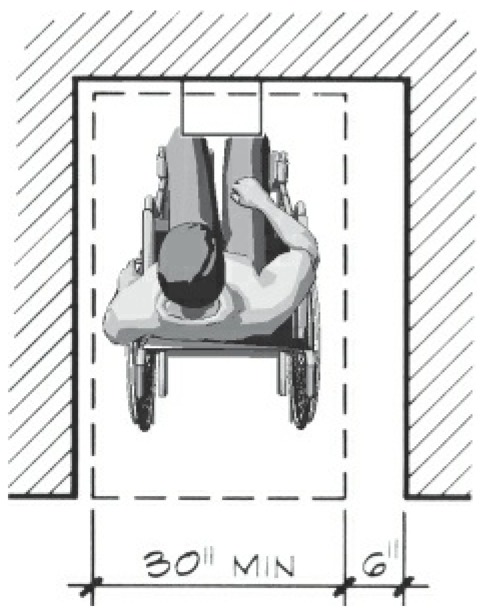


Figure 3.12 Wheelchair space requirements.

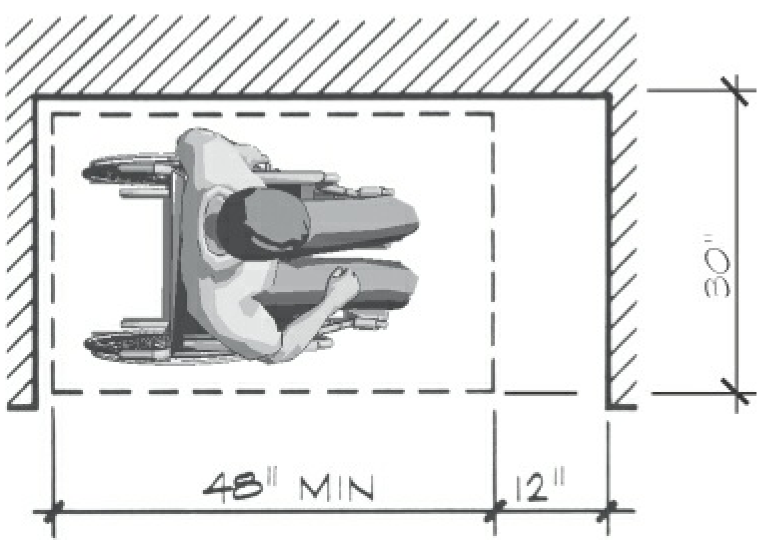


Figure 3.13 Wheelchair space requirements.

Locations for Controls and Shelving. As shown in Figures 3.9 through 3.13, there are dimensional limitations in various directions for a person using a wheelchair. Therefore, controls such as thermostats, window controls, electric switches, pull cords, convenience outlets, and the like will have to be located within these reach limitations. Figure 3.14 illustrates such controls. Another concern in regard to reach limitations is accessibility to the bookshelves found in educational and library facilities. Figure 3.15 illustrates maximum shelf heights and passage dimensions for various types of aisles.

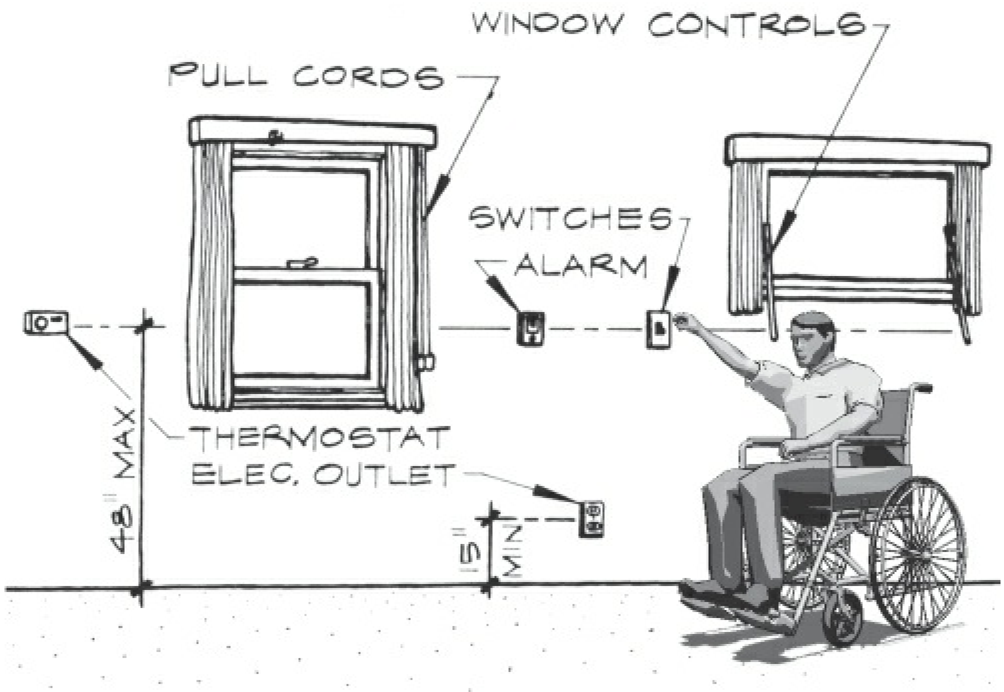


Figure 3.14 Control heights.

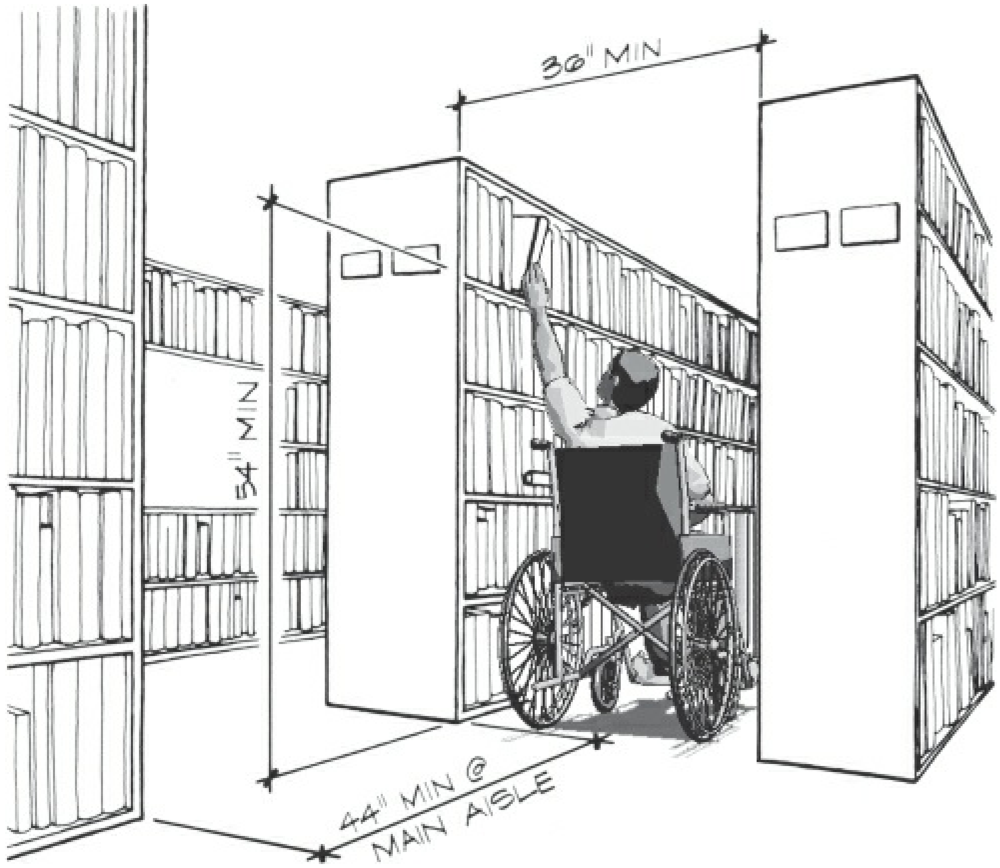
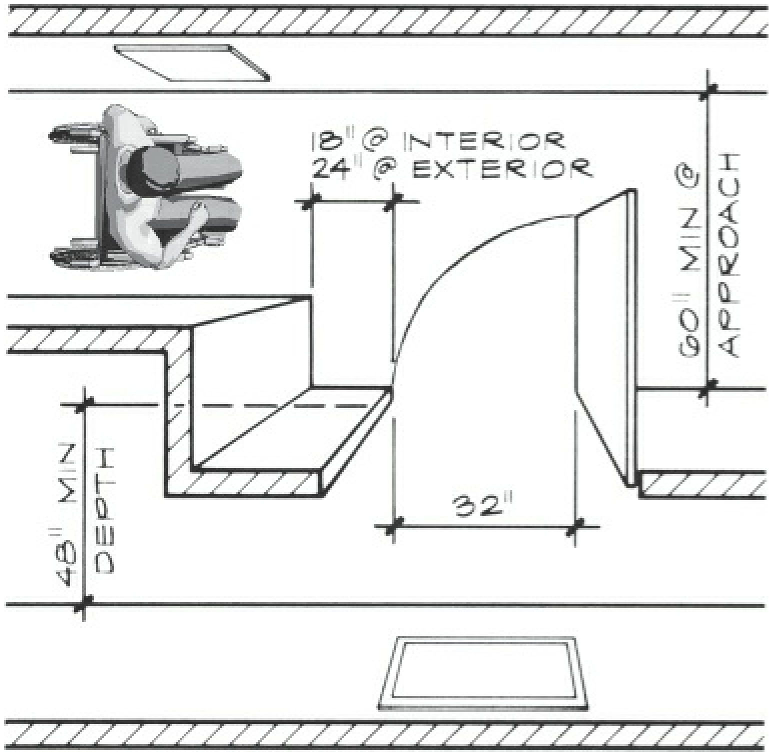
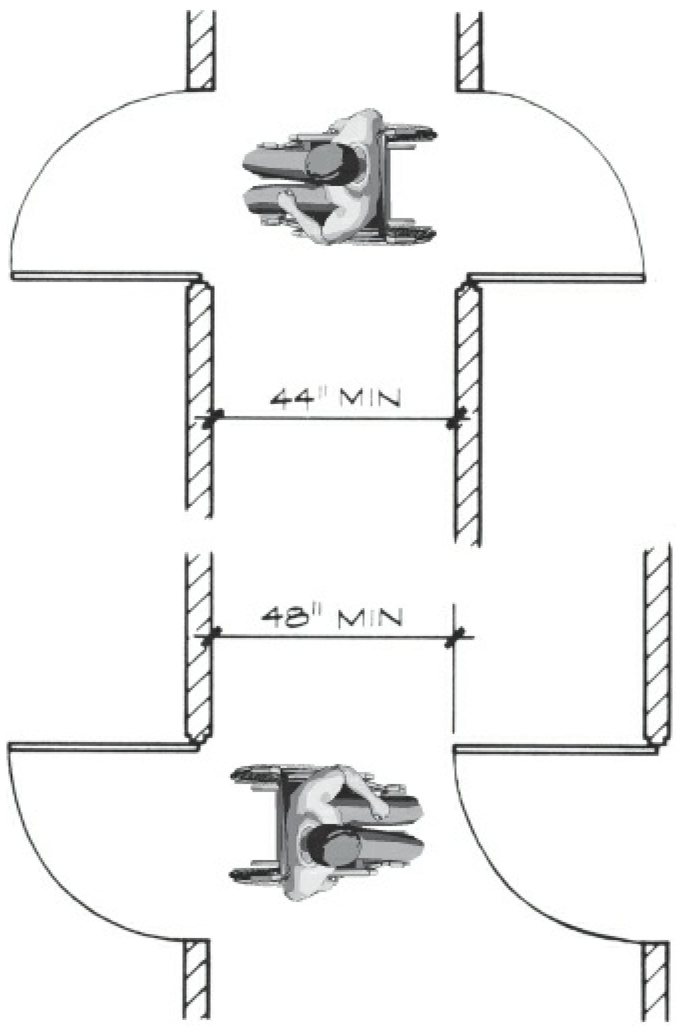


Figure 3.15 Shelf heights.

Doors and Doorways. The maneuvering capabilities of a person in a wheelchair are important considerations when dealing with accessibility of doors and doorways. These capabilities determine the minimum required floor…plan dimensions. An example of a floor…plan configuration involving a door and doorway access is depicted in Figure 3.16. Note that the door clearance does not include the door thickness or any hardware. Door…swing direction in access corridors will be dictated by required minimum clearances for maneuvering a wheelchair to access doors. If building code requirements specify that certain doors have to swing into corridors, then corridor dimensions may have to be adjusted to satisfy wheelchair clearances. Figure 3.17 illustrates two examples of door…swing directions that affect the dimensional width of a corridor.



[Figure 3.16](#) Doorway maneuvering clearances.



[Figure 3.17](#) Doorway maneuvering clearances.

Access doors and the various hardware assemblies required for their functioning must also meet certain requirements. For example, regulations confine the selection of door

handle hardware to a lever…type U…shaped handle with a minimum and maximum dimensional location above the floor. Similarly, the slopes and heights of door thresholds must satisfy accessibility requirements. An illustration of hardware for door handles and an example of an acceptable threshold are shown in Figure 3.18.

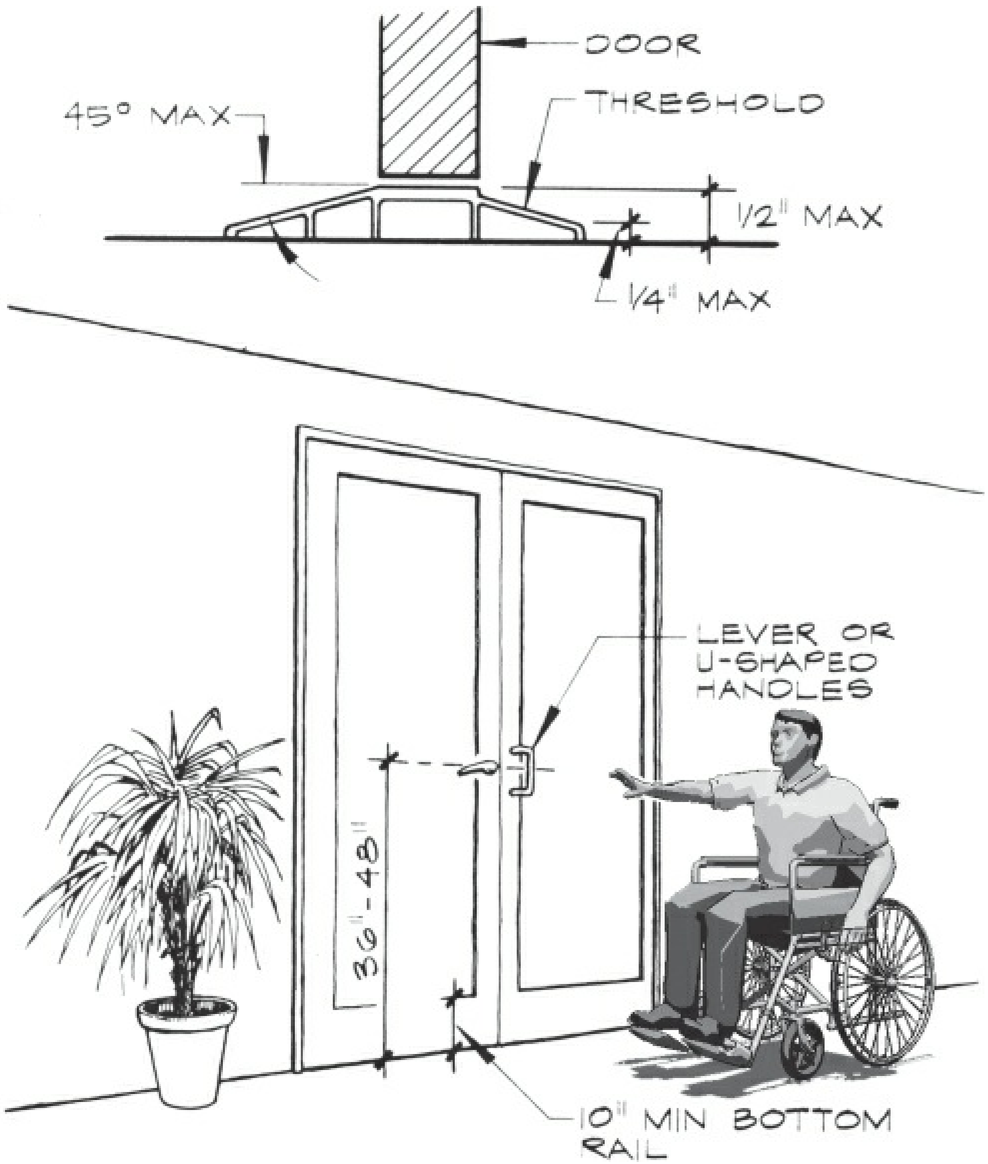


Figure 3.18 Threshold and door hardware.

Drinking Fountains. When planning drinking fountain locations, the architect will have to be aware of minimum required dimensions for recessed or projected installations. Figure 3.19 provides a view of these two types of installation, illustrating dimensional clearances as well as the maximum height to the spout and clearance for knee space.

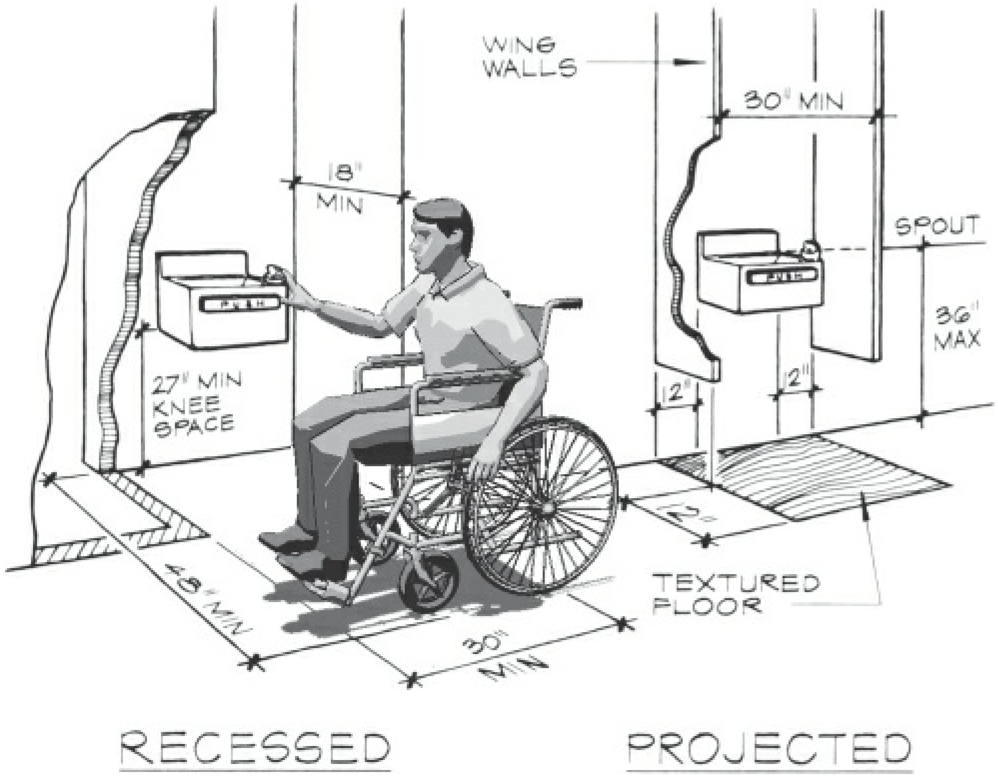
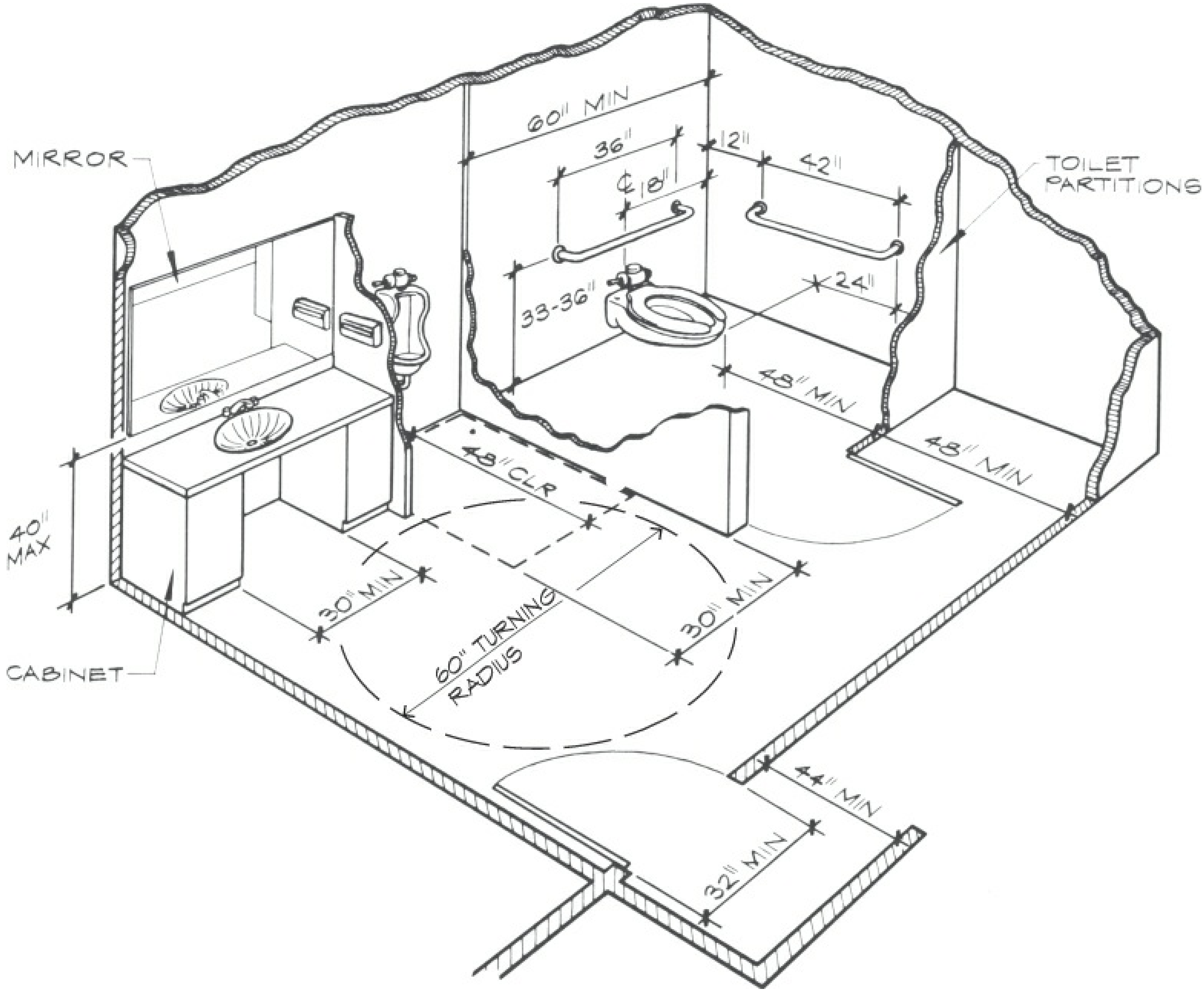
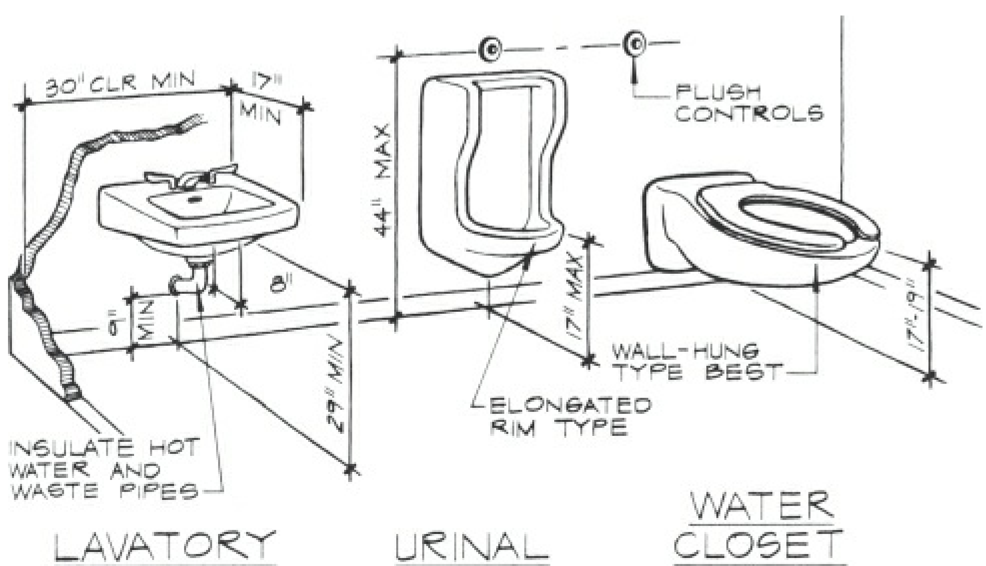


Figure 3.19 Drinking fountains.

Plumbing Facility Requirements. An important facet of the building design process is the provision of accessible plumbing facilities that accommodate persons with disabilities. These facilities, which include such fixtures as water closets, lavatories, and urinals, are planned to ensure accessibility for those who have disabilities. A floor plan must be designed to provide at least the minimum required space clearances and accessibility to specific plumbing fixtures. Figure 3.20 illustrates an overall pictorial view of a proposed restroom facility that incorporates minimum access clearances for the various plumbing fixtures. Note the required grab bar sizes and locations relative to the water closet. The installation of the various plumbing fixtures is regulated with reference to their dimensional height above the floor, side…wall clearances, and knee and toe spaces for the use of lavatories. See Figure 3.21.



[Figure 3.20](#) Restroom facilities.



[Figure 3.21](#) Plumbing fixtures.

Note that hot…water and drain pipes are required to be insulated to protect against

contact. Lavatory clearances are most important, because the knee will project under the lavatory fixture and will therefore require additional clearance. For a clearer illustration of the required clearances beneath the lavatory, see Figure 3.22. In planning for accessibility to toilet compartments, the location of the door to the compartment will dictate the required fixture layout. See Figure 3.23.

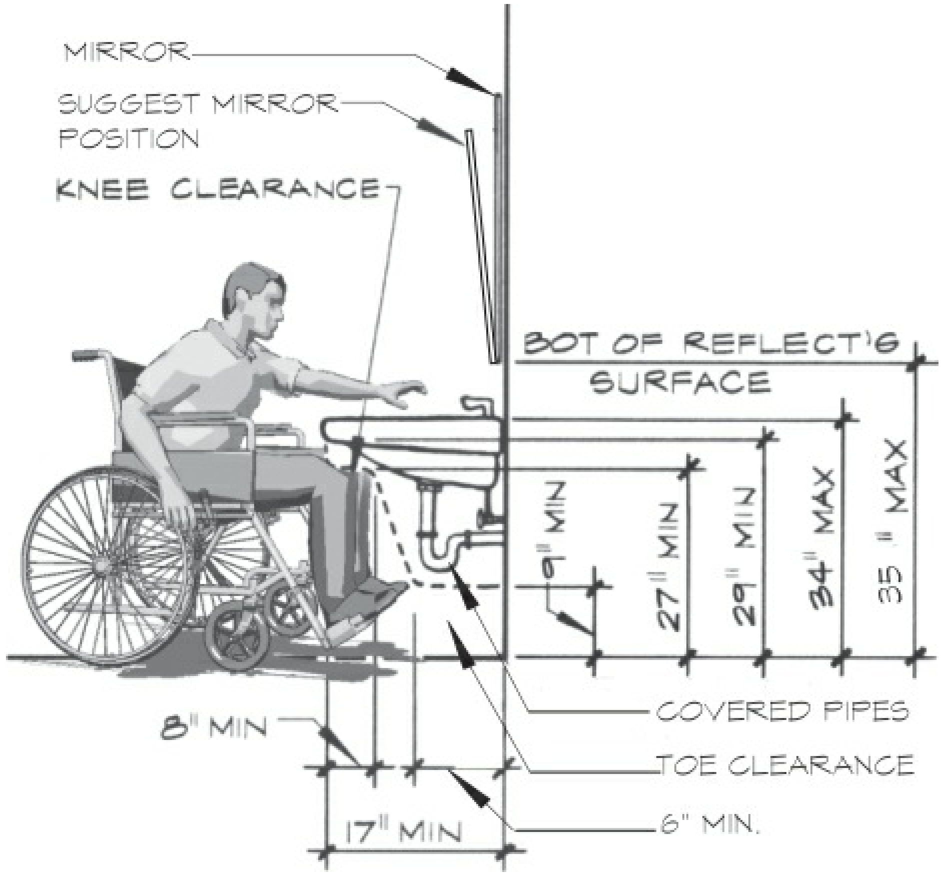


Figure 3.22 Lavatory access.

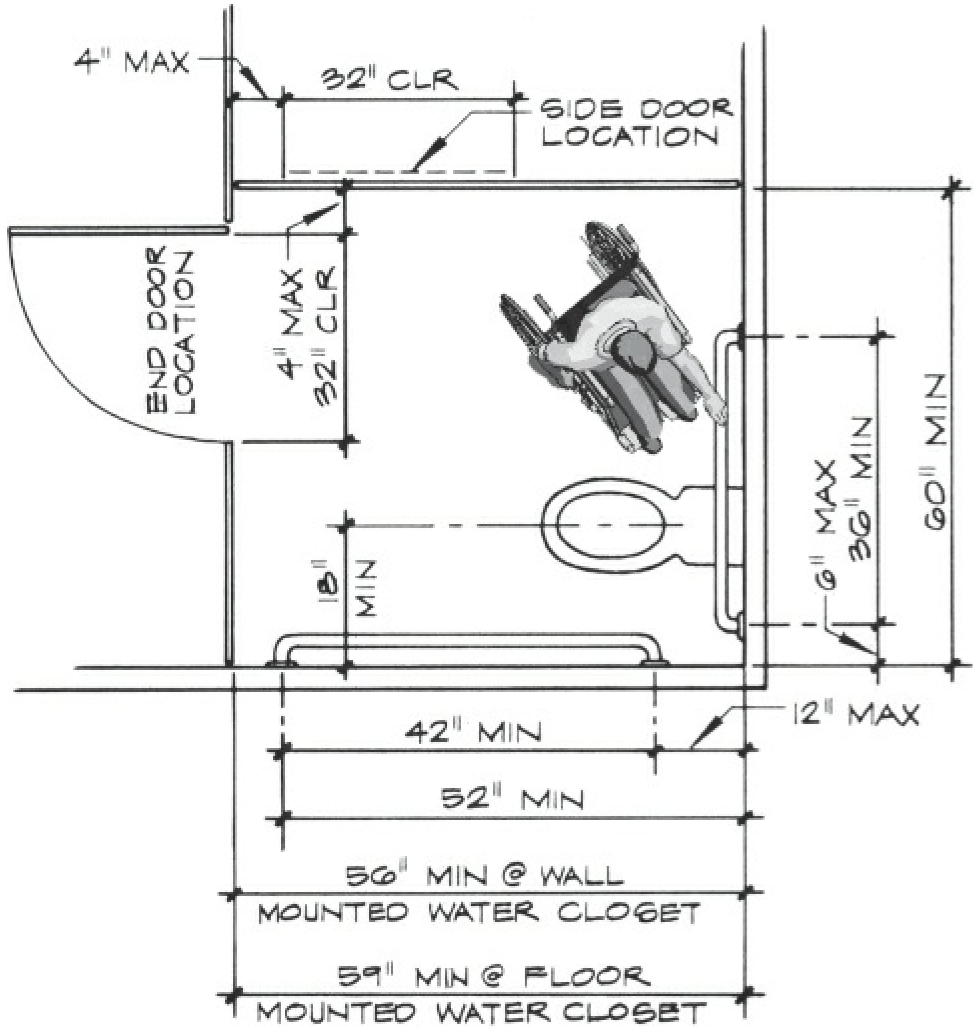


Figure 3.23 Toilet compartment plan.

These illustrations are examples of the elements within a public building that the architect must plan for in order to accommodate persons with disabilities.

We have included a few samples of construction documents (partial plans and elevations) showing how ADA information must be displayed and what types of notes might accompany the drawings. If these drawings confuse you, try reading Chapter 8 on floor plans, and Chapter 11 on exterior and interior elevations, before looking at these sample plans, elevations, and notes again. They are found in Figures 3.24 through 3.27.

LAVATORY

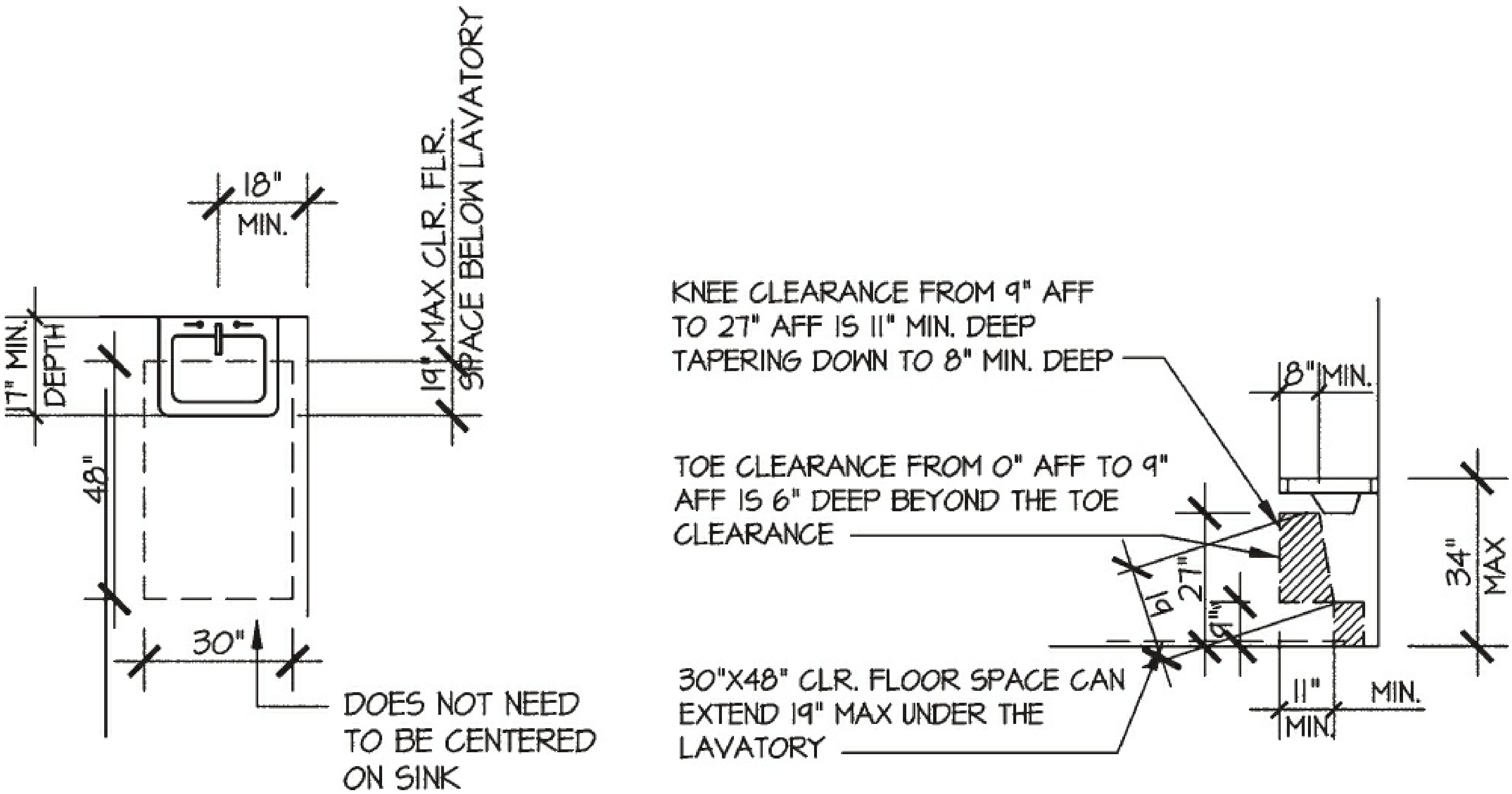


Figure 3.24 Lavatory drawings and specifications.

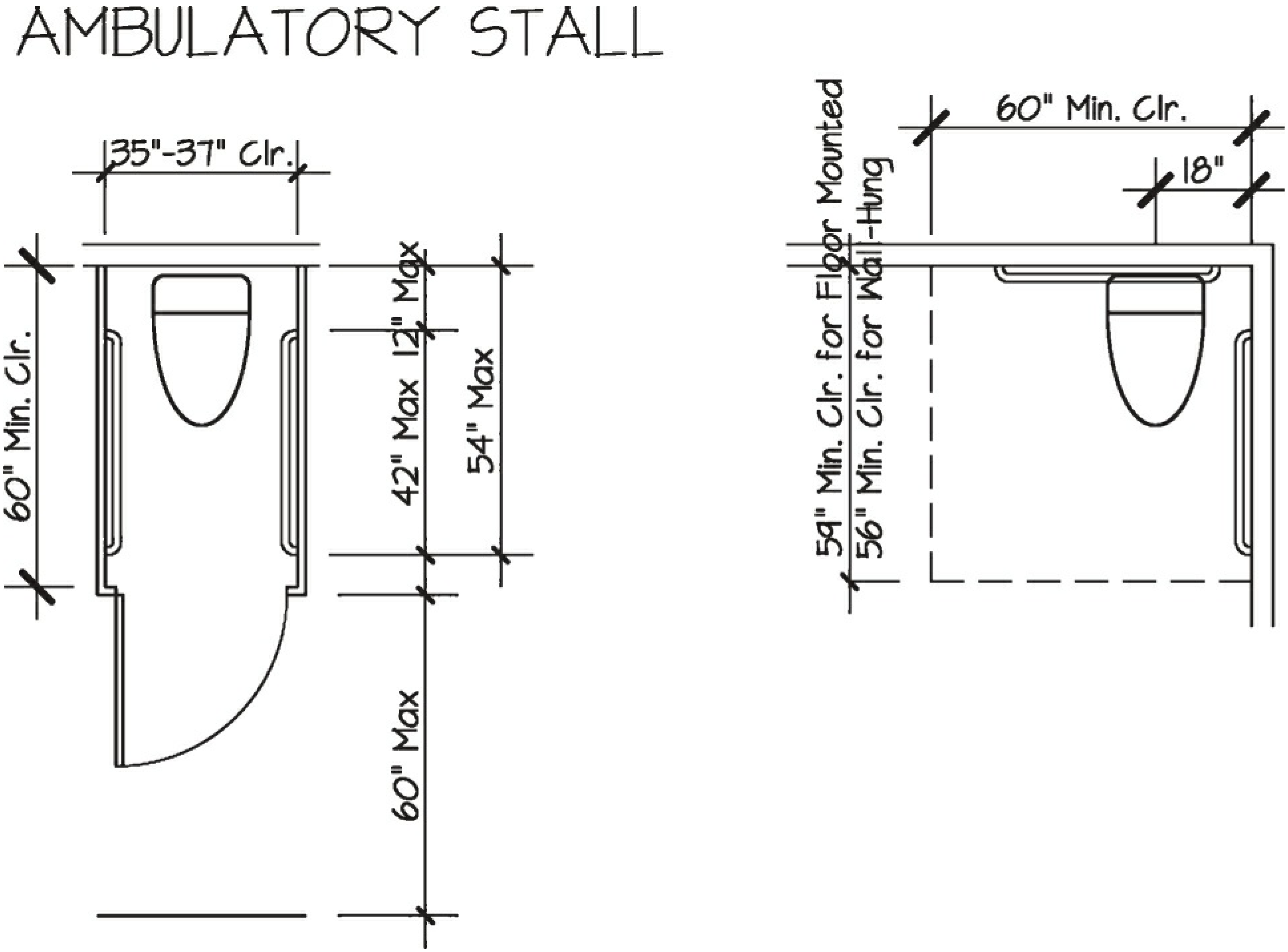


Figure 3.25 Construction documents for a water closet (ambulatory).

Typically, notes such as the ones seen in Figure 3.26 would be found adjacent to the images found in Figures 3.24 and 3.25. It is also possible that the notes could be included in the specification section of the architectural documents. See Figure 3.26.

Notes:

Lavatory:

- All drain and hot…water pipes under the lavatory must be insulated or covered with a boot or shield to prevent contact.
- All sharp and abrasive surfaces under the lavatory must be covered to prevent contact.
- Doors should not swing into the required clear space.

Faucets:

- Faucets must be operable with one hand and should not require tight grasping, pinching, or twisting of the wrist; lever…operated, push…type, and electronically controlled faucets need to be ADA compliant.
- Force necessary to operate faucet controls is 5 pounds maximum.
- Self…closing valves are to remain open 10 seconds maximum.

Water Closet:

- Toilet (single or multiple accommodation):
  - Toilet is located 18″ from the side wall to its centerline.
  - Flush valve is located on wide side of toilet.
  - Flush valve requires 5 pounds maximum force to operate and is operable with one hand and does not require tight grasping, pinching, or twisting of the wrist.
  - The top of the seat is 17″ to 19″ above the finish floor (AFF).
  - The seat does not automatically spring to an open position.
  - The toilet paper dispenser allows for a continuous paper flow and does not control delivery.
  - The toilet paper dispenser is located between 7″ and 9″ from the front of the toilet to the center of the dispenser and 15″ to 18″ AFF.
- Single accommodation toilet:

  Provide a turning space of 60″ diameter in the restroom, with a clearance height of 27″ minimum.

  Above the finish floor, the turning space can overlap clear spaces of other fixtures, and doors can swing into the turning space.

  Or provide a “T”…shaped turning space of 60″ × 60″ with two 12″ × 24″ notches; the turning space can overlap clear spaces of other fixtures and can use the 27″ clear height for knee and toe clearance on one side only.

  Doors cannot swing into the required clear space of any fixture.

  Operable parts of hardware are located 34″ to 45″ AFF.

  Doors within 10″ AFF should have smooth kick plates the full width and 10″ high.

  Provide one minimum accessible lavatory.

  If separate restrooms are provided for each sex, then an accessible restroom should be provided for each sex.

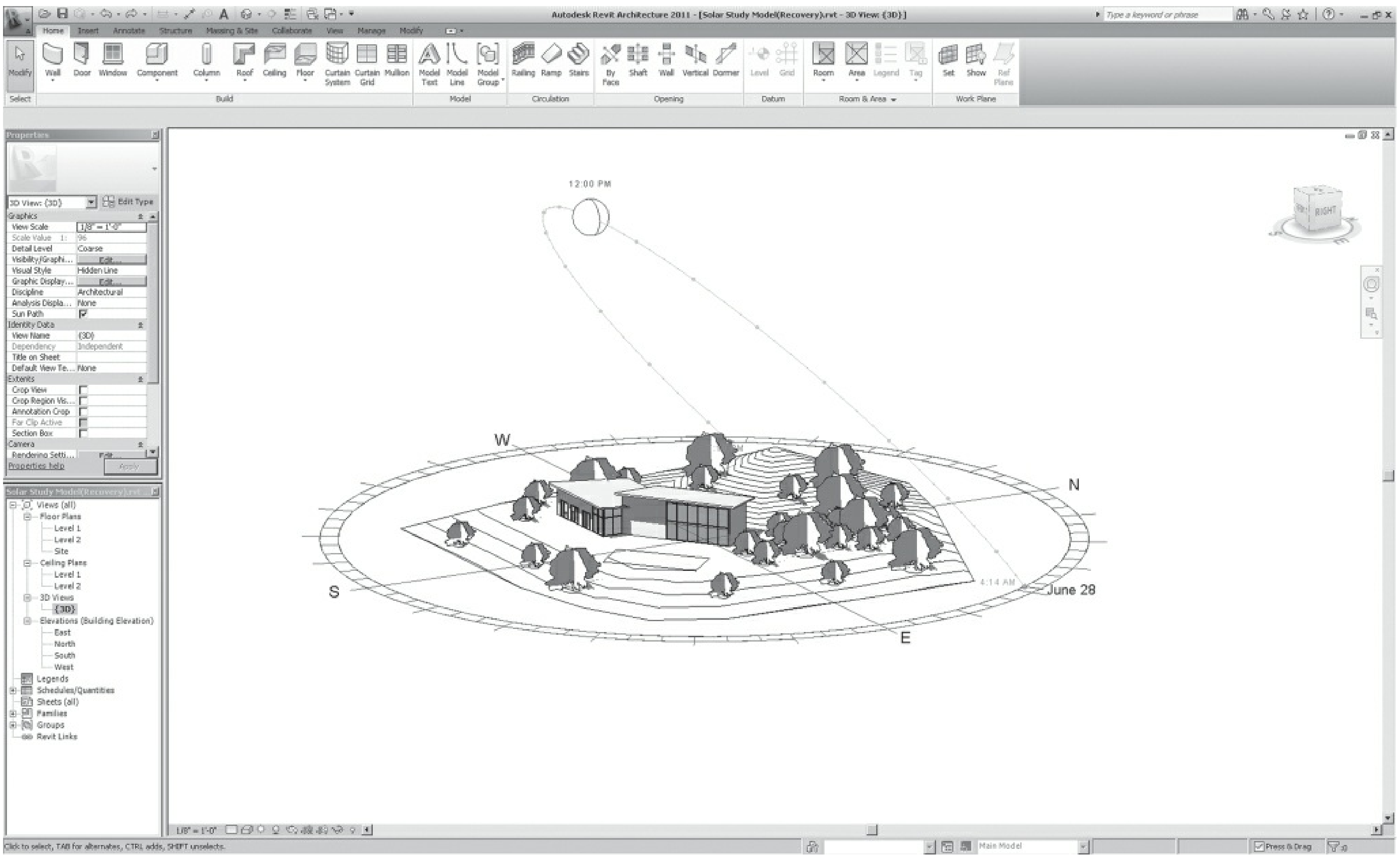
  If a unisex restroom is provided, it should be accessible.

[Figure 3.26](#) Minimum requirements for fixtures, door, and clearance.

BUILDING INFORMATION MODELING (BIM)

Introduction to BIM

BIM has become universal in popularity and has recently spread its wings into not only the United States, Canada, and Central and South America but throughout Europe, the Middle East, most of the Orient, and in fact all over the world. It is a program that looks at the information and turns it into a three…dimensional (3…D) mode. This model can be rotated and seen from above as a plan or look at it as an elevation. In fact, it can create a perspective view (3…D) that can be shown to contractors, expediting and clarifying estimating above all of your clients (see [Figure 3.27](#)).



[Figure 3.27](#) 12:00 noon June 28.

You must know all about the structural engineering and where the beams used will be located, the path of the ductwork throughout the building, the location of the plumbing lines and so on. In fact, the architect or the designer of the structure will need to know all of the facts of the building, early during the development of the project. The profession calls this “front loading,” but it must be done to use BIM effectively.

Initiating BIM

Of the many technical programs available that will initiate BIM, it must be carefully selected, and then carefully reprogrammed to follow office standards that have previously been established or, if you are presently not employed, must change the existing programs that you subscribe to and implement national standards, some of which were included in the previous chapter.

One aspect that is usually missed is the printer or plotter. You can check by drawing a sample rectangle at a given scale and plot, then measure it with an actual scale. If it does not measure correctly, then the printer setup must be reprogrammed (please review this step in Chapter 2). Otherwise, you are sharing an incorrect drawing with your client, contractors, and all for the individual concerned with the building. Those who are new to architecture or have just interceded in BIM and its technical working aspects should go to Chapter 15.

BIM is a new way to approach construction documents, particularly working drawings. BIM addresses every characteristic of a building, from material quantities to energy performance, from lighting to site disturbances (to mention just a few). BIM can be an integral part of sustainable design because it allows the architect/designer to explore, investigate, and implement designs that have the least impact on the environment.

In architecture, as in life in general, there is nothing as constant as change. Fortunately, BIM manages change for you. It also keeps you honest, as it does not allow you to avoid a situation by temporarily inserting a “placeholder” unit in your design. BIM is data driven. It allows you to take a design and enhance its data, but it does so in a holistic manner. This means you cannot be fickle: the change you make on any plan or elevation will be reflected in all drawings. For example, if you put a window on the first floor of a three…story building, using BIM will change the window alignment on the other floors to accommodate it. The program is “parametric” modular; that is, it creates and maintains relationships among elements. Therefore, you must always work in three dimensions. You must see the impact the floor plan has on other drawings. A two…inch change in the columns between floors on a 10…story building will have a monumental impact on the surface of the elevations. Again, to use BIM successfully, you must work with a 3…D model.

BIM and Energy Considerations

BIM can be used with software tools that analyze energy use. With these capabilities, we are able to quantify the green effect of our structures much earlier in the design stage. Those involved with the project (the design team and the client) will be able to “walk through” the virtual structure so as to actually visualize and see the results and effects of greener design.

For example, we can study lighting via tools that allow use of airport information about the weather at any given latitude and longitude on Earth. In this way, we can see the

effects of daylighting. **Daylighting** refers to using natural lighting (sun) to illuminate the structure, thus reducing the use of electrical energy to light (and heat) the building. Thus, high…performance, sustainable design can be realized by using the multifaceted approach made possible with ease via BIM. This is critical in current design, because structures (both residential and commercial, of which there are approximately 81 million in the United States) account for about 40% of all energy consumption in this country. It is our buildings that create the energy shortage! We used to blame automobiles and other vehicles, yet they alone account for only 7% of our energy use.

Federal agencies, state governments, and local governments are all helping to finance green building, whether by grants, tax credits, or other schemes. There are also regulatory incentives from state and local government entities. Architectural firms are eager to employ individuals who are Leadership in Energy and Environmental Design (LEED) certified, as that status enhances the chances of success when bidding on government… funded projects such as schools.

Autodesk Green Buildings Studio (GBS), a tool used for building energy analysis. GBS creates a thermal model of the building and even applies local building code presumptions. This can (and should) be done throughout the design stages. Early use enables better orientation of the structure on the site. Daylight can be checked during the design stages. Also, GBS creates an input that, in turn, enables engineering analysis systems to be used in conjunction with Revit for detailed analyses. This automated input of geometric coordinates saves hundreds of hours of labor. Revit's hidden strength is its ability, when used correctly, to provide information effortlessly, accurately, and quickly.

You can even do estimates of LEED credits for use of recycled material in your draft specifications, as well as reducing waste and improving staff efficiency. Because Revit knows what materials are to be used, it will automatically know what to draw; all it needs is for the drafter to input the size of the room.

Architecture and Trust

Since the time of hand…drawn construction documents, architects have been very protective of their work product. Protection meant keeping the originals and only releasing the prints (usually printed in blue and not capable of being copied). They protected their designs as well as the processes used in the construction documents, such as details to realize their drawings. Copyrights were (and still are) available for architectural renderings and plans, but were used by only a few firms because the application process was quite lengthy and time consuming. Consequently, the government made copyrights a high priority in its scheduling.

When computers were introduced, the problem of theft and pirating became acute. Over the years, such portable storage devices as flash drives made it very easy for drafters to copy construction documents or parts of them, such as a detail that was time consuming to produce. When the draftspersons moved to another office or firm, they carried with them a library of conventions and shortcuts that made them quite valuable to the new

employer.

Details especially are unique to each job. Nevertheless, poor drafters were using a lot of details on every job without knowing the consequences given the new job characteristics, such as soil conditions, transfer of load (shear transfer), and so on. More experienced drafters would repurpose and reuse their details as datums, tweaking the detail to accommodate weather conditions, moisture conditions, and load…bearing details. Unfortunately for them, details can never be a standard for an exterior bearing wall, because of the infinite variety of soil and other conditions.

Computers also made transmission of construction documents easy because one could quickly send them to, say, the structural engineer via electronic mail. Hard copies were not needed because the electronic files could be sent immediately. Of course, electronic transmission exacerbated the problem of plagiarism, as files could be easily copied, especially after the introduction of wireless units. Protection was installed in the form of blocks, but for every block, a computer hacker found a way in.

Architects were also outsourcing drawing tasks to other countries where labor was cheaper. The work got done seemingly instantly, as the projects were being sent to countries with approximately 12 hours' time difference. This meant the offshore crews were working while domestic ones were sleeping, so drawings were being produced 24 hours per day. One serious drawback to this system was its negative effect on change orders: havoc was produced when changes in the floor plan were not properly communicated and therefore were not made in the other drawings, such as the elevations, sections, and framing plans, to mention just a few.

The advent of BIM solved many of these problems, but also created additional ones for our profession. The use of BIM requires us again to build trust as we travel full circle. From jealously protecting and guarding our drawings, details, and innovative ideas, we have had to come to trust our associates—whether in…house or outside the office—with our entire BIM/Revit product. This trust brings us back to the beginnings of our profession and the way its members used to work: sharing, delegating, collaborating, and trusting as a new way of building a new community within the architectural profession. As a medical surgeon must trust his or her operating…room colleagues (such as the anesthesiologist and surgical nurses), so must an architect build a common, thoughtful bridge between contractors, their subcontractors, and the structural, civil, and electrical and mechanical engineers.

Any large contractor will claim that this is not now being done by architectural firms. Therefore, contractors are building their own models based on the 2…D drawings they are given, needlessly re…creating a model form that already exists. In addition to demonstrating mistrust, this duplication of work adds cost to the project. The concept of BIM depends to a great extent on not duplicating files, but rather having access to the original working file.

To best understand the problem, look at Figure 3.28. In this model, the architect becomes the coordinator and resolver of conflicts. This is very difficult to do with a 2…D drawing.

Even a trained eye may miss a duct that conflicts with a structural member or a plumbing or electrical line drawing that conflicts with a beam in the framing plan. Often, mechanical engineers will lay out their equipment while overlooking or ignoring the fact that the other engineers and trades need to use the same space. Such conflicts can be avoided by the use of BIM because it shows the structure holistically in 3…D. If all of the engineers would input their information into a single source, any conflict that arises would be shown immediately. In this way, Revit catches human errors in our construction documents that the senior drafter, the job captain, or any of the staff in an office might miss. See Figure 3.29 for a picture of this coordination of associates.

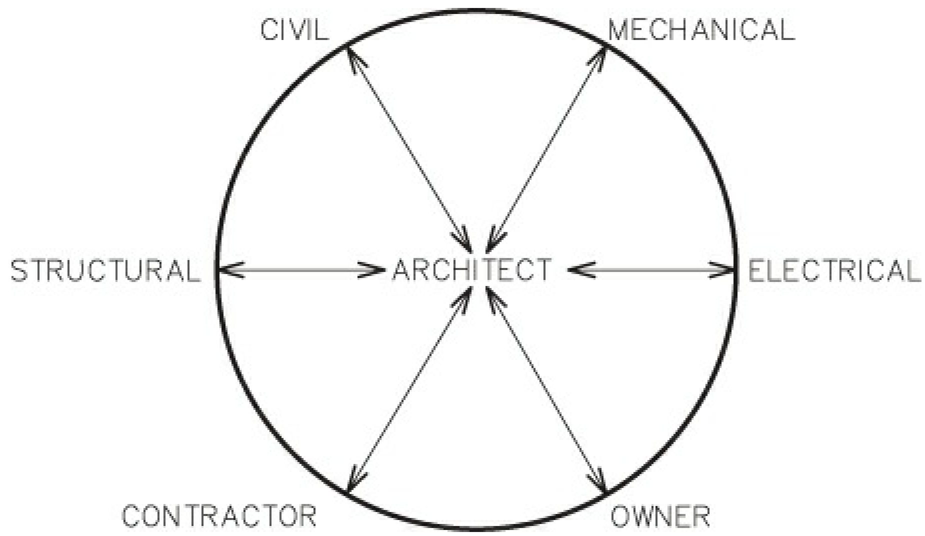


Figure 3.28 Disseminating project information to owner and professional associates.

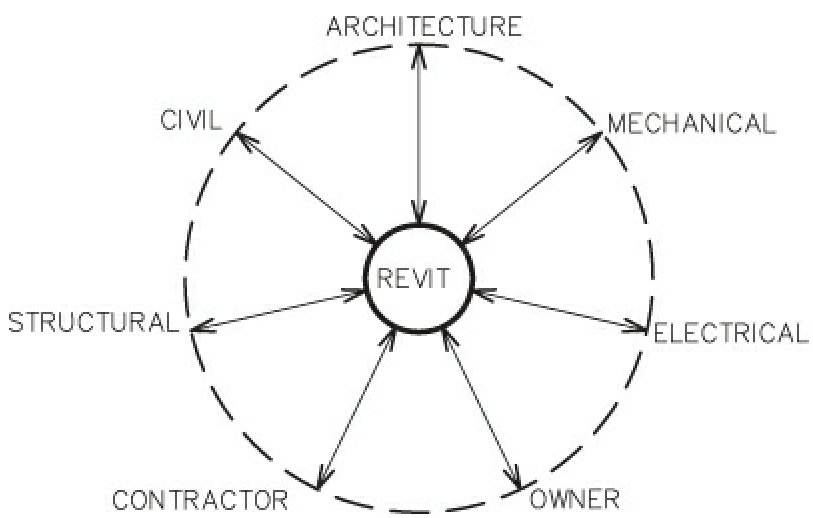


Figure 3.29 Coordination of drawings to catch conflicts.

Because BIM is still so new to most drafters, they often fall back to using AutoCAD because they are comfortable there. Even when Revit, a powerful parametric modeling tool, is used, we see drafters drawing in 2…D rather than 3…D. This is okay for the moment, but eventually we hope that the entire profession will use 2…D drawing only when it is absolutely necessary, and even then continue thinking in 3…D.

As for BIM, it creates a fine line between design, development, and construction documents. When design development is finished, the construction documents (working drawings) will also be all but finished.

A Thought

There are many reasons for the slow adoption of even very promising new methods. The situation somewhat parallels the process of changing from use of the English system to use of the metric system. The older drafters were not eager to learn a new skill, and even the younger professionals were not as familiar with or trained in computer use as they are today. Forty years ago, the original computer games were quite simplistic, and video games did not catch on until more sophisticated games were produced later on. Computers were not as sophisticated as they are now, and telephones were still land lines. Over the past 40 years, things have drastically changed: Today's students grew up with text messaging, the Internet, Facebook, and so on. For them, the transition to AutoCAD is easy, as young pupils are intimately familiar with computers and how they work. Quite a few are bona fide computer geeks who can manipulate software and hardware to make the computer do anything they want it to do.

The learning curve for the transition from AutoCAD to BIM is even steeper. BIM requires much more than a translation or acquisition of skills: It demands greater and deeper knowledge of architecture and construction. To complete a 3…D drawing, one must change what has been learned in 2…D to a finite 3…D drawing. The front…loaded drawing programs of today require the designer to solve architectural problems, such as conflicts in the positioning of air…conditioning ducts, plumbing, and structural components, up front, well before the construction documents stage and early in the BIM process. This is a disadvantage to the present CAD drafters, who often depend on their skill with AutoCAD rather than their architectural skills to solve their problems. This is why the offices using BIM/Revit must set up a template that the drafter can follow. Too much computer skill and too little architectural knowledge can be deadly to an architectural project.

Summary

The BIM concept has revolutionized the design process and changed how production drawings are produced. At the same time, it has enhanced the use of sustainable/green architecture, thus allowing designers to earn as much as 20 LEED points in the process.

Changes have blurred the distinction between the functions of the designer and the drafter. In fact, many firms have eliminated the terms **draftsman** and **draftsperson** and instead train for their particular uses of Revit.

The main drawback to BIM lies in the need for reeducation of our staff. As educators, we need to look at the needs of architectural offices and find a common denominator for producing a Revit…based curriculum.

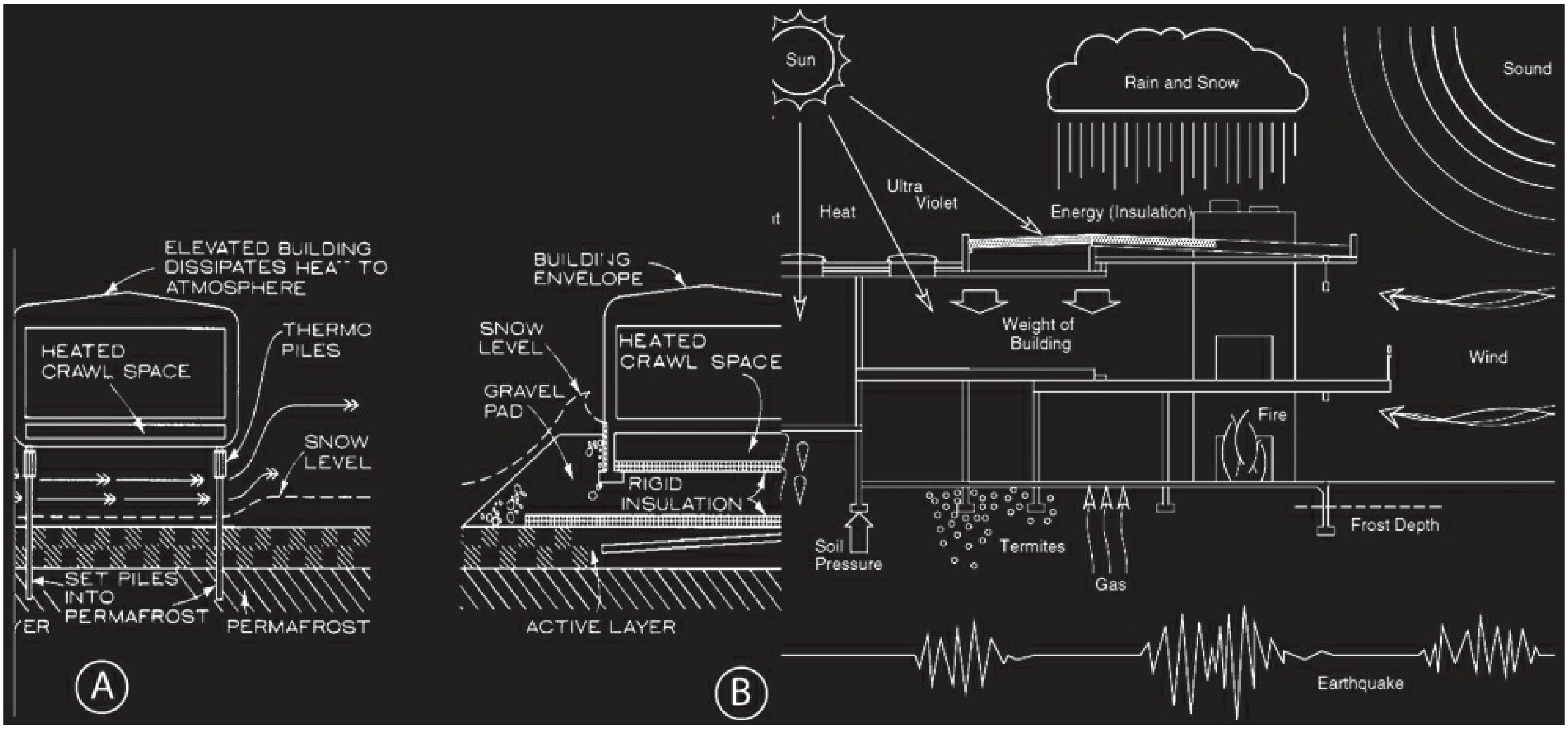
The entire thinking process has changed. Our drafters need to be able to understand how buildings are built and work in 3…D first, before they attempt to use Revit. To be useful in the BIM process, a drafter must be able to produce details in their final form, cut sections, and be more focused on drafting and drawing conventions.

We must educate our drafters to be substance drafters rather than surface drafters, not just to know how Revit works, but to understand how Revit can produce structures that are fully thought through. BIM is the new concept, and the computer tool, of our profession.

Key Terms

- anthropometrics
- Architectural Graphic Standards
- ergonomics
- daylighting
- draftsman
- draftsperson

Chapter 4
SUSTAINABLE/GREEN ARCHITECTURE



ENVIRONMENTAL AND HUMAN CONSIDERATIONS

Definition

As the title of this chapter suggests, **sustainable** and **green architecture** has to do with environmental concerns and what architects, engineers, and students of architecture can do about confronting the crisis of energy, conservation, waste, and so on. If everyone in any facet of the architectural profession takes on the responsibility of addressing these issues, an improved outcome can be expedited.

Introduction

One cannot place a building on a site without considering the impact the structure will have on the immediate environment. In fact, there are many environmental concerns facing the architectural technician, ranging from seismic to snow, from the effects of the sun to rainfall, and from the control of termites to frost…line depth in certain regions. The results of a national survey conducted by the authors on environmental concerns are printed in the Appendix A survey of regional differences and can be found on the web site for this text at www.wiley.com/go/wakita. An abbreviated list of the most common concerns includes:

1. Climate
2. Soil/geology
3. Seismic activity
4. Fire
5. Energy

6. Foundation design
7. Flooding
8. Distribution of loads/roof loads/vertical loading
9. Structural design
10. Frost depths
11. Drainage
12. Insulation
13. Americans with Disabilities Act (ADA)
14. Water table
15. Exterior finishes

This chapter specifically addresses sun (light, heat, and ultraviolet radiation), sound, deterioration of materials, termites, and underground gases (see Figure 4.1).

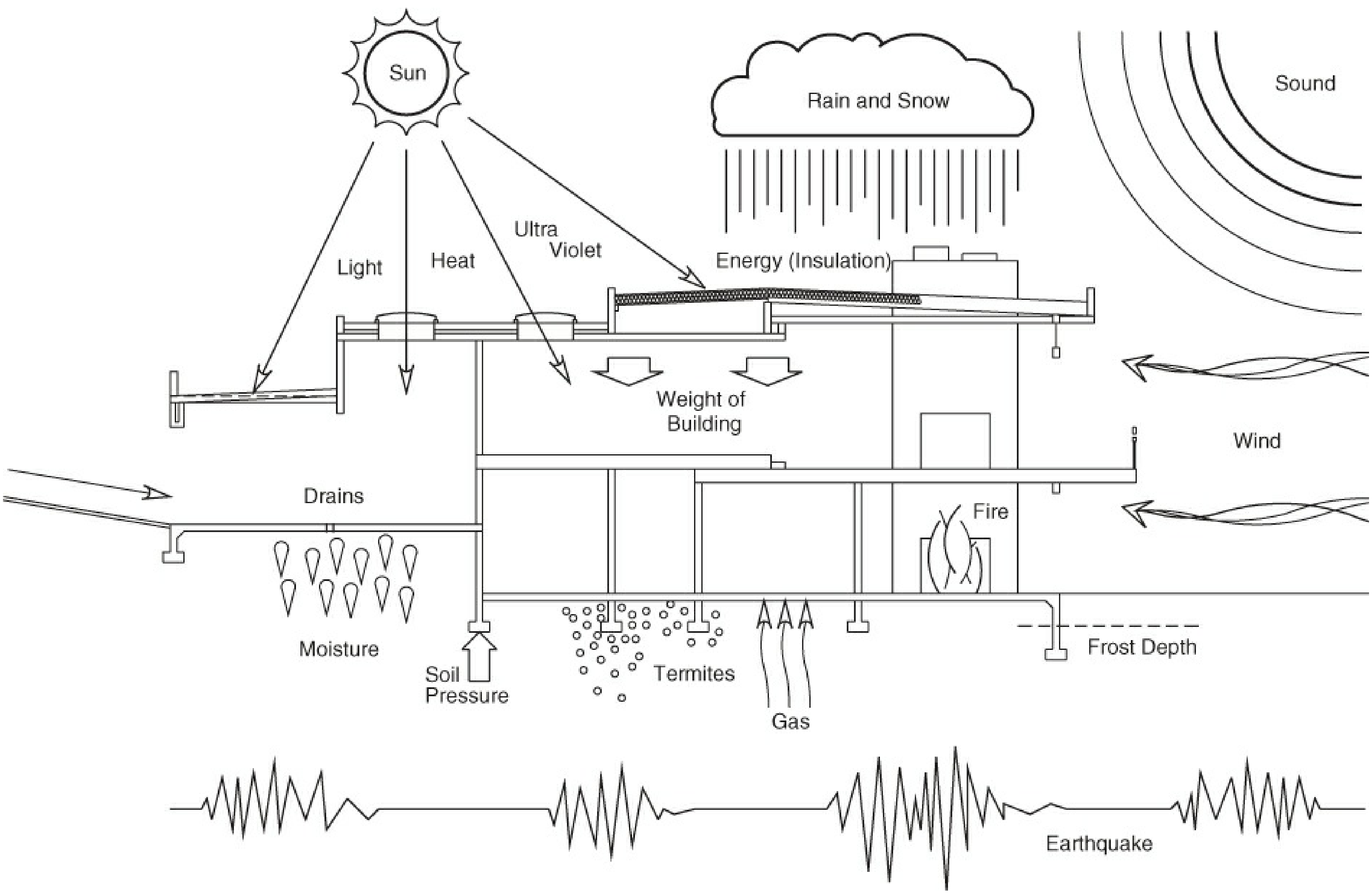


Figure 4.1 Natural forces.

SUSTAINABLE ARCHITECTURE

The term *sustainable architecture* has different meanings for different individuals. For some, it may be as simple as incorporating a solar unit to heat the water for a structure. To others, it may mean harnessing all the forces nature has to offer to sustain a structure. A third—and more comprehensive—approach is to calculate the load that a designed structure produces on its immediate surroundings and to provide a solution that successfully reduces this load via natural forces, such as the sun, wind, heat gain and heat loss, and seismic (among others).

In any event, this may be a moot point, because a responsible architect, through his or her formal training, will in the design process call upon all the applicable and naturally available technology to produce the safest and most efficient structure possible. This chapter was written to highlight a few of the concerns that may confront architects and the solutions they may employ to address these concerns. Review Figure 4.1.

Solar Shingles

We are now incorporating solar energy into our homes and business structures. Solar panels are not only very popular but can be incorporated into the design a number of ways including the use of photovoltaic shingles into the roof during the initial designing preparation stages. To this end, we encourage manufacturers to produce solar shingles that blend with our existing configurations in such a manner that the roof looks natural in color and form. At the present time, there are a number of companies that design integrated tile…solar systems. However, they are expensive and people are shying away because of the initial cost. Hopefully, practicing architectural professionals in the know will encourage the existing vendors to seriously study and reduce the cost. See Figure 4.2.

Figure 4.2 Solar shingles.

NATURAL IMPACT

Lateral Influences

Structures are affected by either high wind conditions or seismic activity/impacts (earthquakes), or both. In many cases, one will be the obviously larger factor, but in either situation, the structure will be required to resist the impact forces. Figure 4.3 illustrates a simple rectangular building and the wind pressure on its sides. The total wind pressure is calculated at the roof and floor diaphragms. This factor is expressed as a force acting on these diaphragms, as indicated by F…1, F…2, and F…3. The diaphragms are considered rigid planes and will distribute the forces into vertical bracing units.

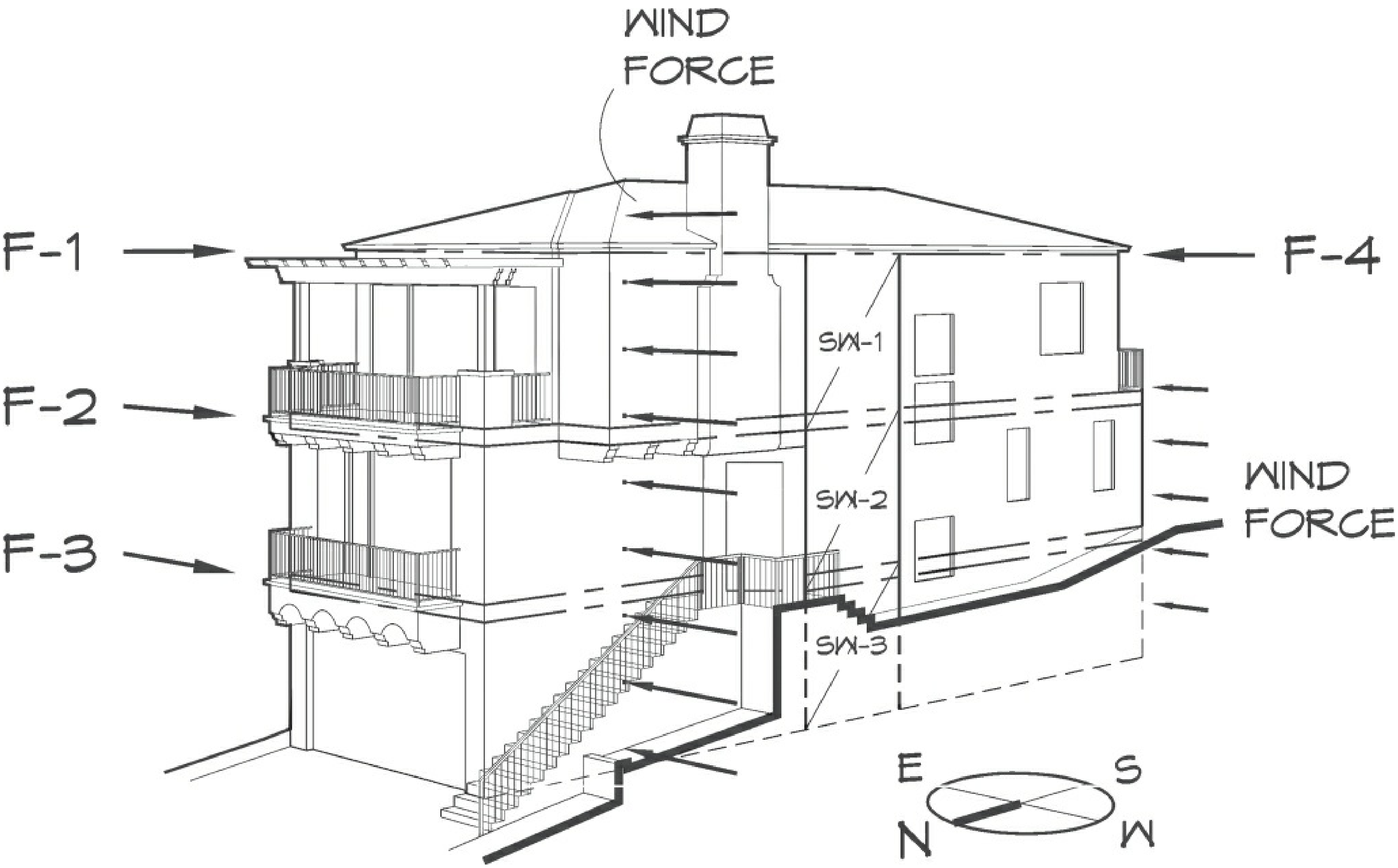


Figure 4.3 Lateral forces on a building.

The following are three examples of vertical bracing methods that an architect or structural engineer may implement to resist the lateral forces impinging on the building shown in Figure 4.3.

Figure 4.4 depicts a portion of the west wall in Figure 4.3, where the lateral force F…4 is distributed into the engineered plywood or oriented strand board (OSB) shear walls. The thickness of the plywood panels, the shear connectors, the panel edge nailing, the strapping, and the field nailing are all determined by the force they are intended to resist. The seismic loads, derived from earthquake forces, are generated by the dead weight of the building construction materials. Wind loads are determined by use of historic wind… speed data specific to the building site. The force factors distributed throughout the structure are resolved for seismic impacts in a manner similar to the way forces created

by wind conditions are resolved.

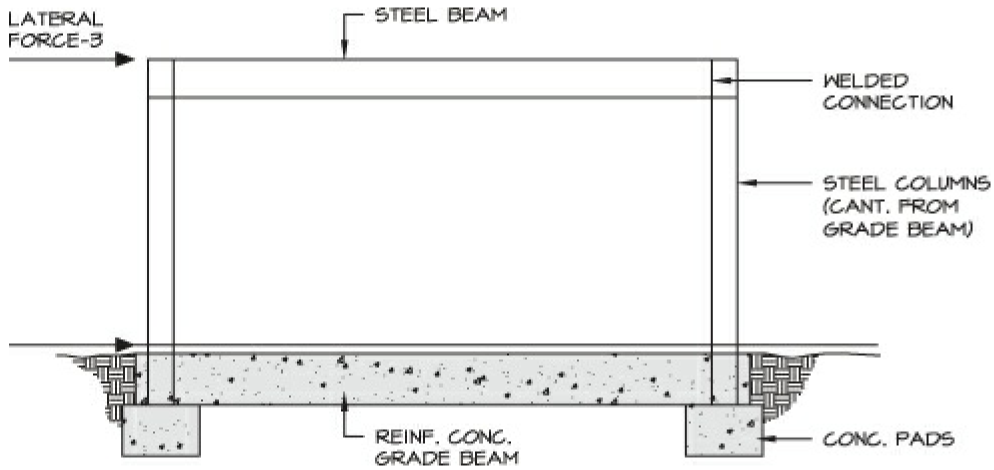


Figure 4.4 Example of steel frame with cantilevered columns.

Figure 4.5 depicts a steel frame at the opening at the north side of the first‐floor level. Windows and garage doors limit the opportunity to use long, rigid wall areas, such as plywood or OSB shear panels, so in that application, steel is a desirable solution. The steel columns are cantilevered from a reinforced concrete grade beam. This method may be considered a self‐stabilizing frame when used in pairs, or may be called a flagpole design when used as a single column. This frame would resist the lateral force F‐3.

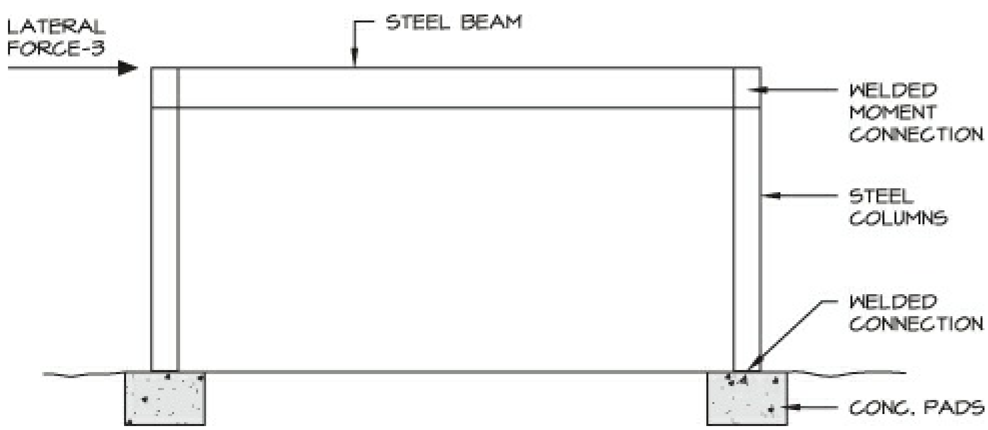


Figure 4.5 Example of steel moment frame.

Another method for resisting the lateral force F‐3 is the use of steel columns and a steel beam with welded moment connections at the steel columns and beam connection. This method may be termed a **moment frame** (also referred to as a **rigid frame**). Such a resistive system is named for the moment connection joints within the steel‐braced frame. This would be utilized in place of the system shown in Figure 4.5 when the column width or depth is limited. This method is illustrated in Figure 4.6.

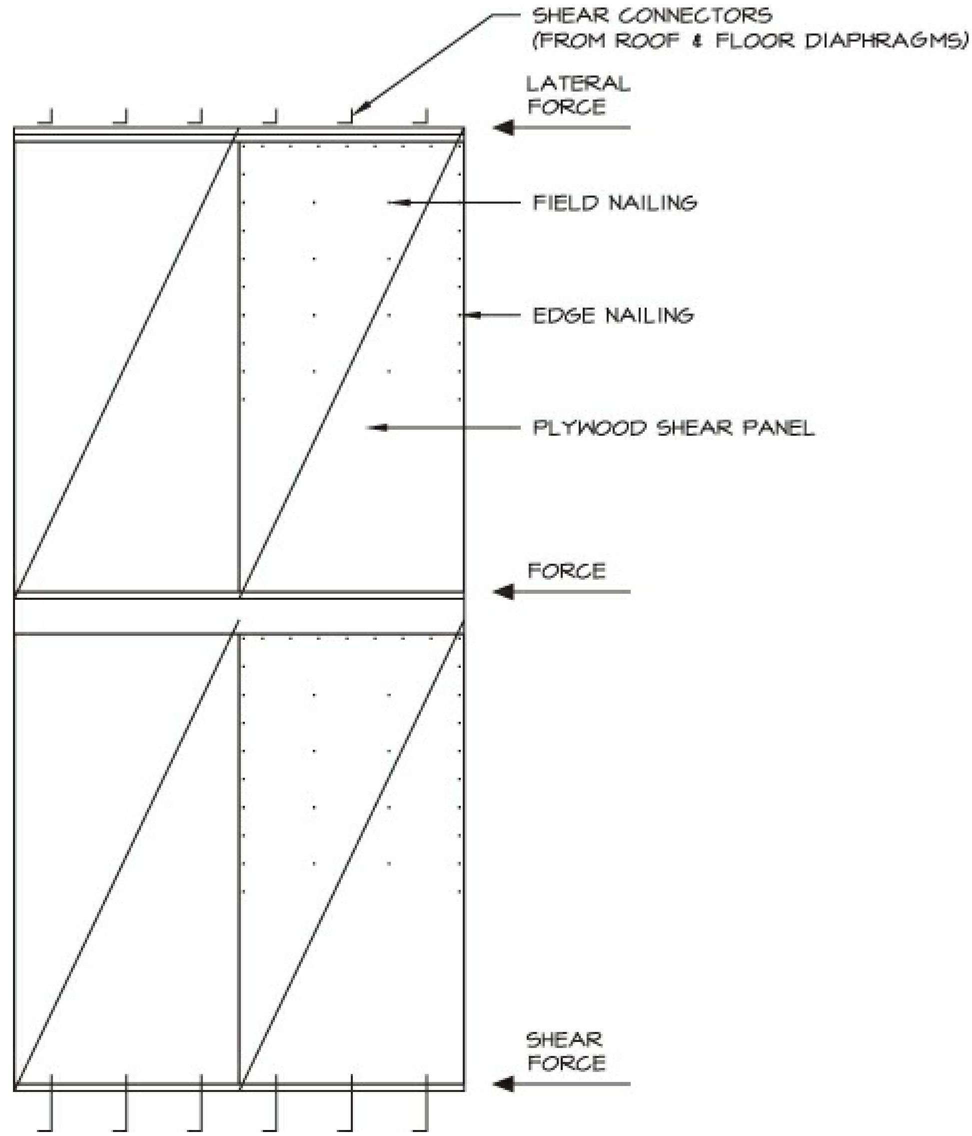


Figure 4.6 Plywood shear panels.

Energy Conservation

The architect, mechanical engineer, and electrical engineer will constantly be designing and providing methods to conserve energy. These methods will primarily deal with the use of insulation allocated to the roof, wall, and floor assemblies for a specific structure. The assemblies will handle both cold and heat, as well as mechanical and electrical systems, and any innovations that will assist in conserving energy.

Figure 4.7 illustrates a three…story residence in which the entire envelope will be calculated, detailed, and constructed with energy…conserving elements designed to address both warm and cold weather conditions. The first elements are the roof, ceiling, walls, and floors. These will be insulated with a material with an “R” value that will resist heat loss and heat gain. The R value is the value assigned to a specific insulating material or a combination of materials that have been tested for their resistive capabilities. One method of combating heat and cold is shown in an example of a roof and exterior wall assembly with insulation at the ceiling and wall locations (see Figure 4.8).

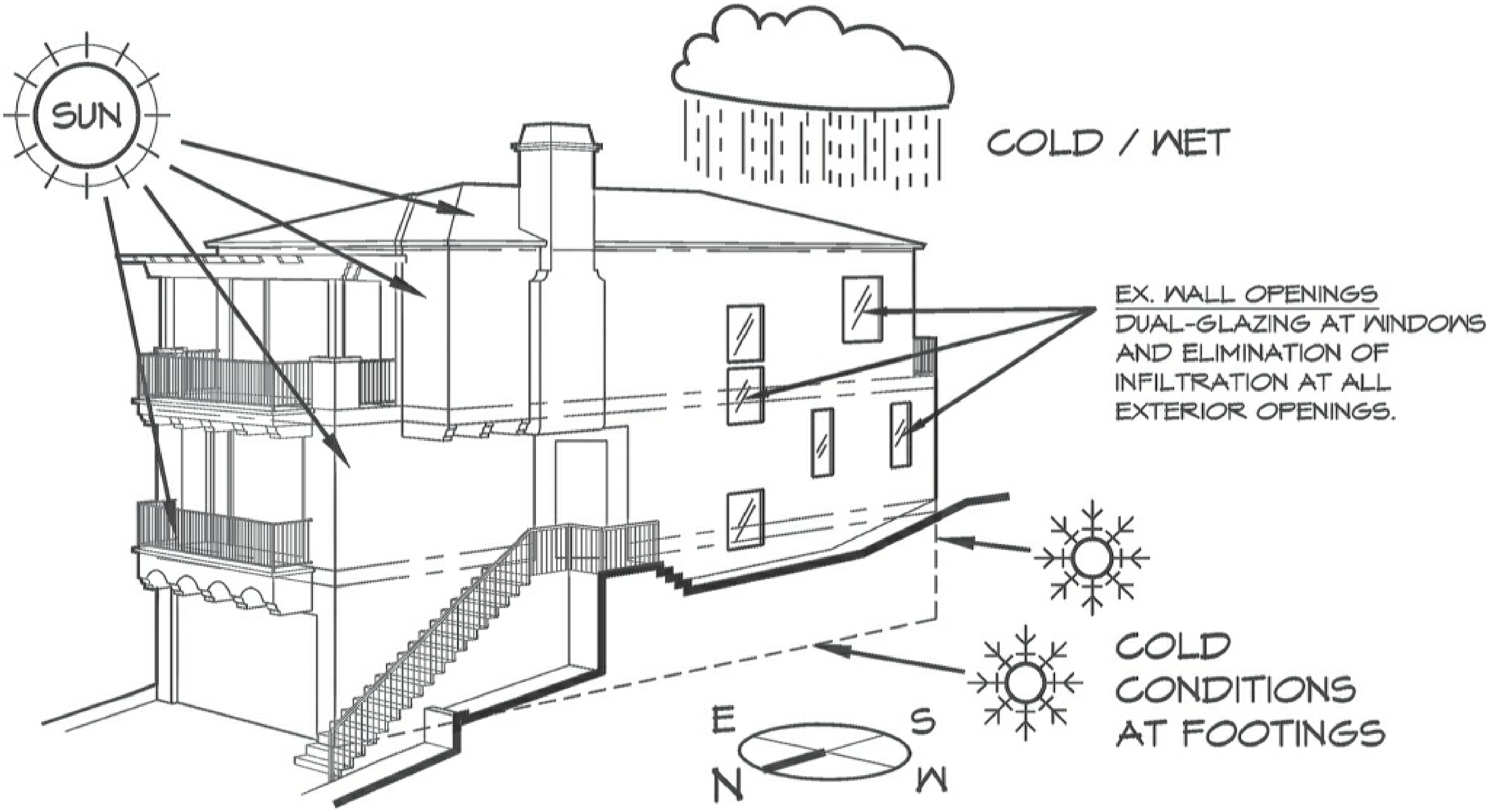


Figure 4.7 Weather conditions affecting energy conservation.

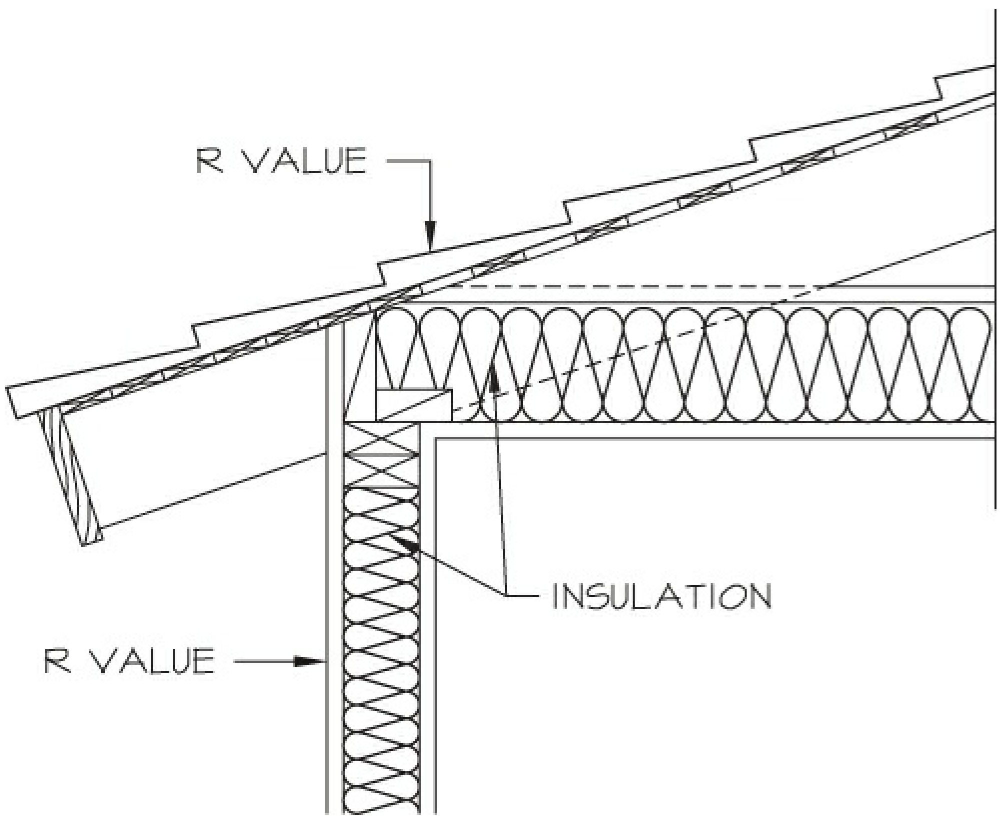


Figure 4.8 Roof/ceiling and wall insulation.

In areas where extreme cold weather conditions prevail in the winter, it is recommended that rigid insulation board be installed at the foundation, around the footing elements, and perhaps under floor slabs. This insulation will prevent excess cold from reaching the floor slab and, ultimately, the inside of the building. Figure 4.9 shows an example of a

footing detail where 1″ rigid insulation board is incorporated at the footing and concrete slab connection. This detail would lower the need for heating and thus reduce the expenditure of energy.

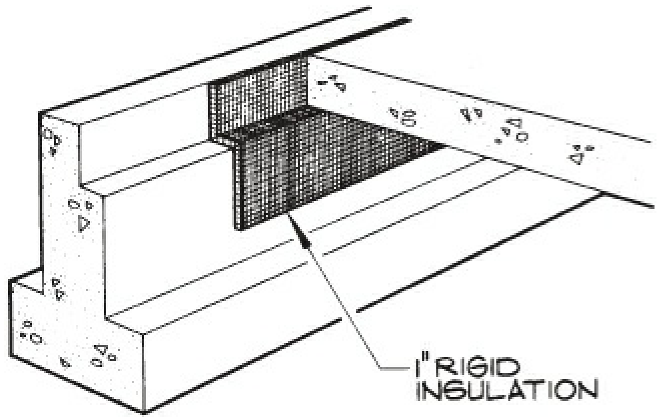


Figure 4.9 Footing insulation.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

For exterior wall openings, such as windows and doors, where extreme cold and hot weather conditions prevail, it is recommended—and in many municipalities required—that the windows have dual or triple glazing and be installed to prevent air infiltration. Doors should also be weather…stripped and installed to prevent air infiltration.

For many building projects, there may be methods and innovations for heating and cooling systems whereby energy conservation may be attained. One example of supplemental heating is the use of a trombe wall. A trombe wall is a large, massive wall that is typically oriented to absorb the most sunlight during the day; it then radiates the heat back into the living space in the evening when the heat is required to maintain a comfortable temperature.

As mentioned previously, the entire envelope in Figure 4.7 will be calculated and designed with energy savings in mind. **Envelope** is a term referring to the entire enclosure of the interior living space of a building. This enclosure may utilize insulation materials to prevent heat loss during the winter and heat gain during the summer. An example of a building section for a one…story residence that creates an insulated envelope is illustrated in Figure 4.10.

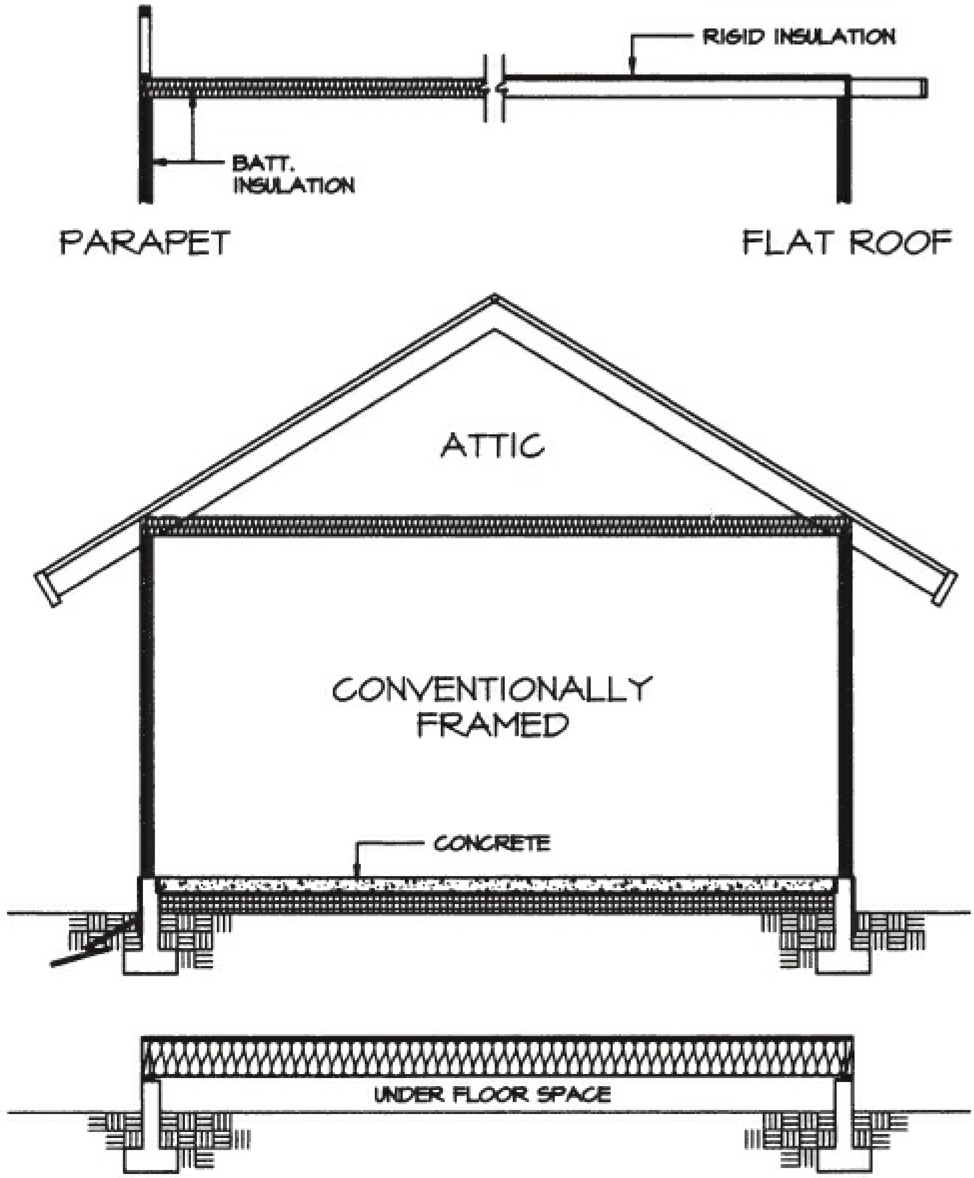


Figure 4.10 Creating an envelope.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

For the purpose of augmenting lighting conditions in interior spaces, devices such as manufactured skylights and a unit called a "Solatube" are recommended. The Solatube, a reflective tube, is attached to the roof, and a lens is directed to an interior space in the structure. The lens refracts the captured light and disperses it into a specific area. This device can reduce the demand for additional lighting energy.

These and other resources are available for conserving energy in building projects.

Snow

In geographic areas with snow and prevailing cold climates, the various sections of a structure must be detailed to address these climatic conditions.

As shown in Figure 4.11, the roof structure initially will be designed based on the live load of the snow. This live load figure is usually established by the existing building code in the local municipality. The load may be reduced for each degree of a roof pitch that is

more than 20° where snow loads are in excess of 20 pounds per square foot. Special eave requirements are set by the governing building codes. These requirements include a hot or cold underlayment of roofing material on all roofs from the edge of the eave for a distance of up to 5 feet toward the roof edge.

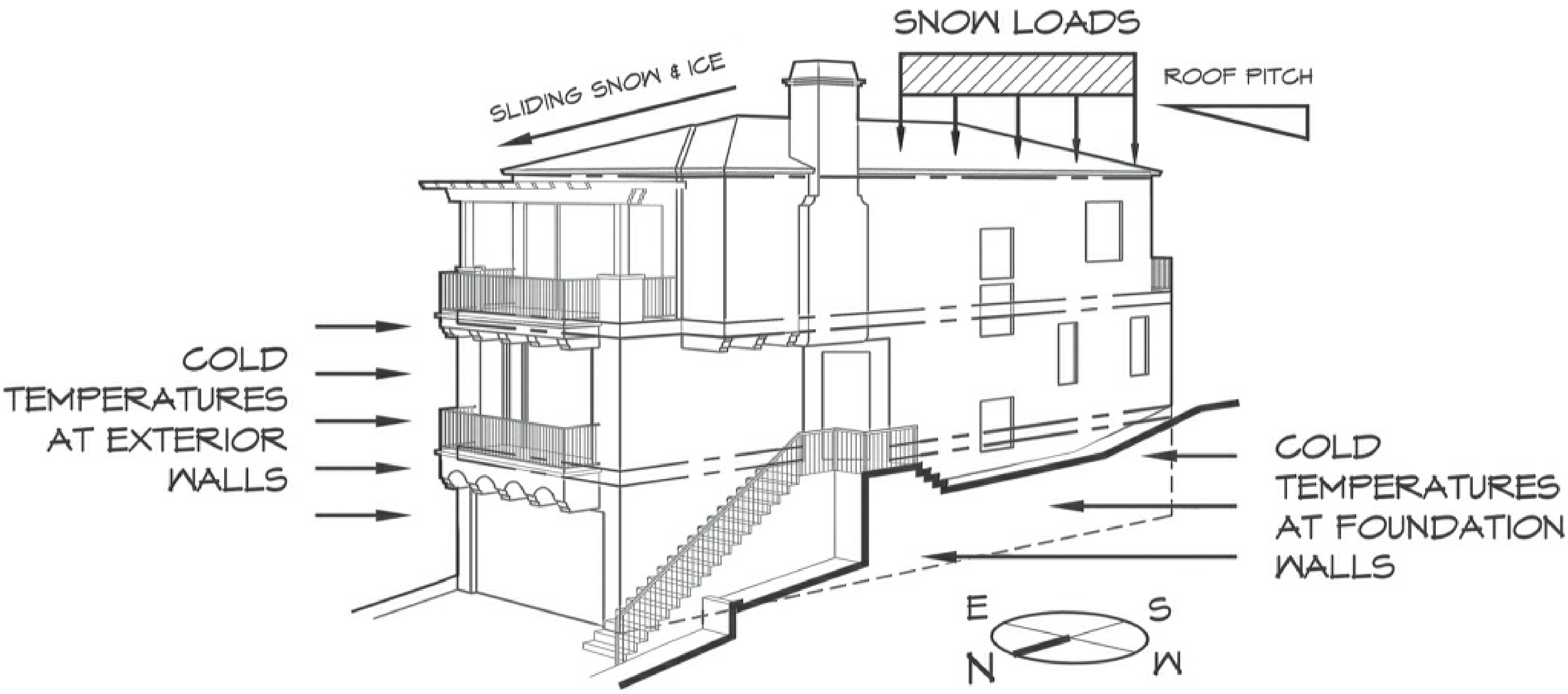
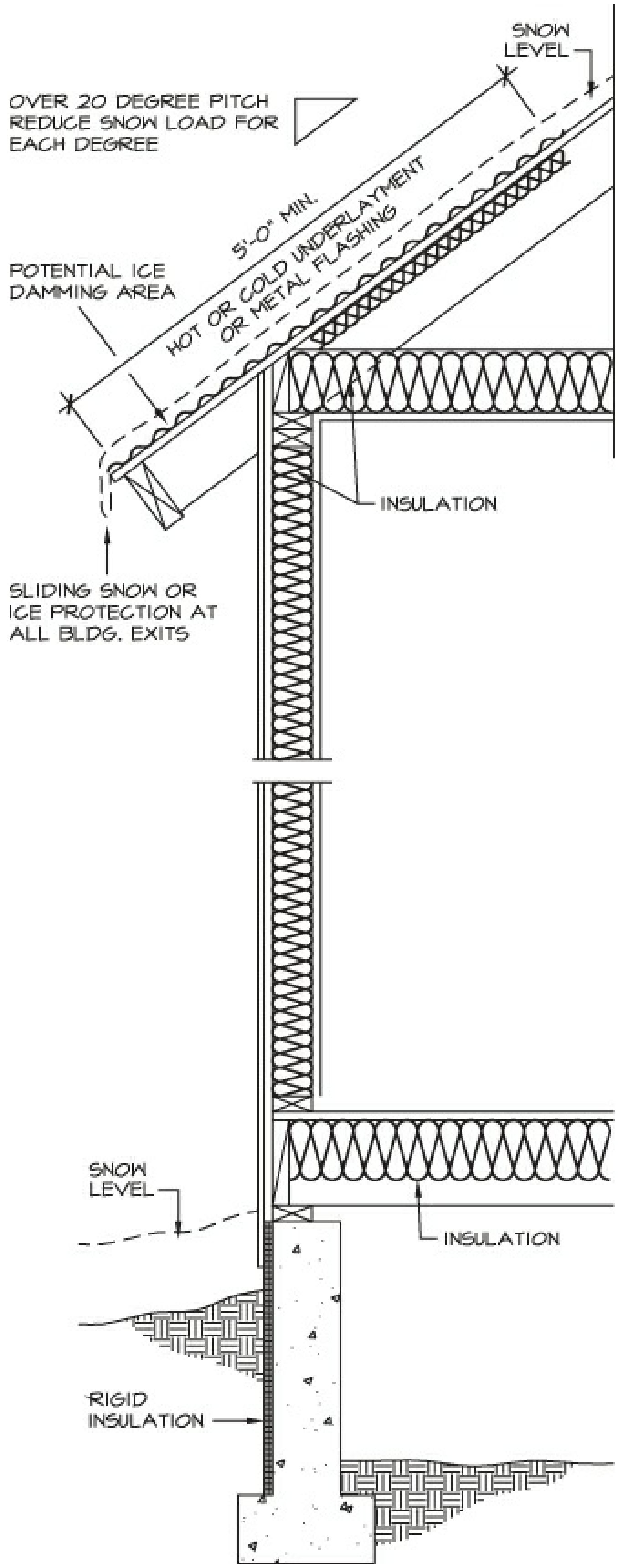


Figure 4.11 Snow conditions and concerns.

It should be noted that in areas that are subject to seismic activity, the building official of the municipality will ask that the snow live load also be calculated into the architect's or engineer's lateral design.

It is a good practice, as well as a requirement of the building code, to protect all building exits from sliding ice and snow at the eaves. The use of heat strips and metal flashing at the exit areas in the eave assembly is an acceptable method of deterring ice dams and snow accumulation. Most roof structures with a roof pitch exceeding 70° are considered free of snow loads.

Insulation is required for roof, ceiling, wall, and floor locations. Rigid insulation board is installed at the exterior of the foundation to keep the utility spaces from freezing. See Figure 4.12.



[Figure 4.12](#) Roof/ceiling and wall insulation.

Temperature

Outside temperatures affect the design of building structures. In areas with high temperatures, buildings are insulated and provided with various types of mechanical systems to control the temperature within the structure's habitable areas. Temperature

also has a large effect on the structural integrity of a building. For example, buildings that are constructed with a concrete frame and a concrete floor system are detailed at various connections to allow for expansion and contraction of the various concrete elements affected by temperature fluctuations. Figure 4.13 shows a concrete column and a concrete floor beam connection that provides expansion joint clearances, as well as an electrometric pad for ease of movement. Such a pad need not be anchored; it is shock absorbent and returns to its original shape and dimension (the soles of basketball shoes are made of this same material). Electrometric pads are best used for putting temporary gymnasium wood floor over concrete floor.

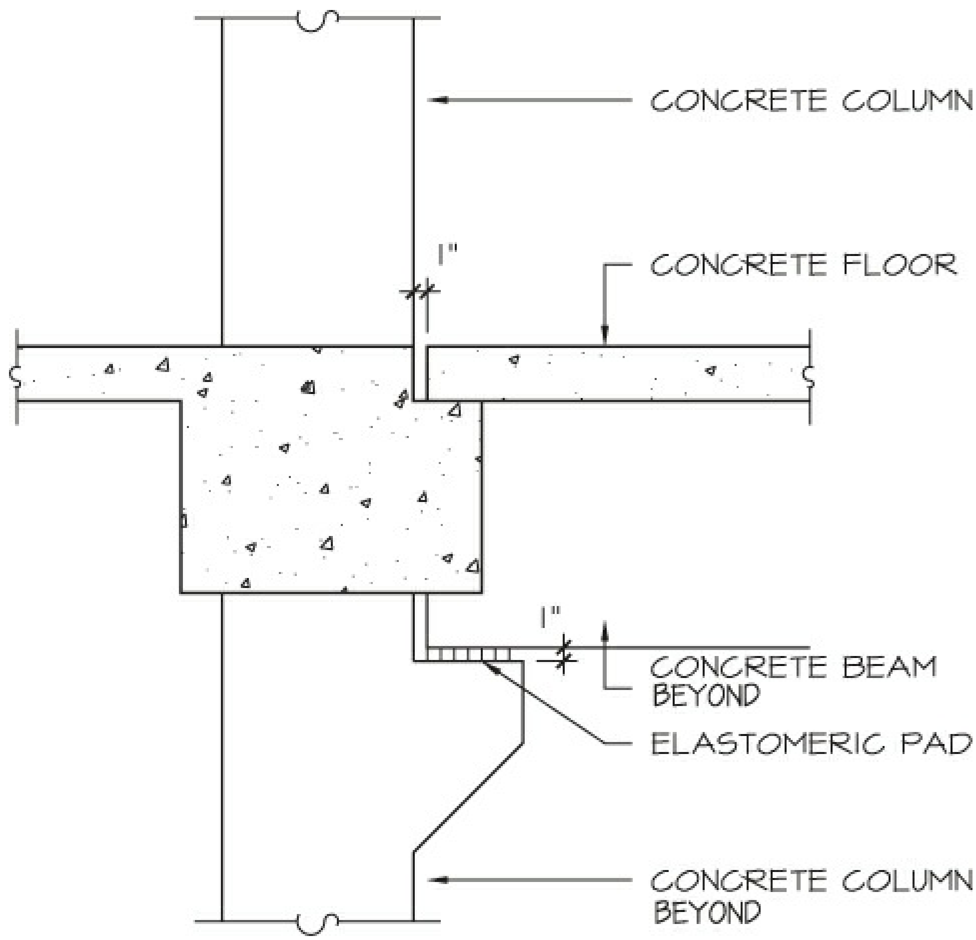
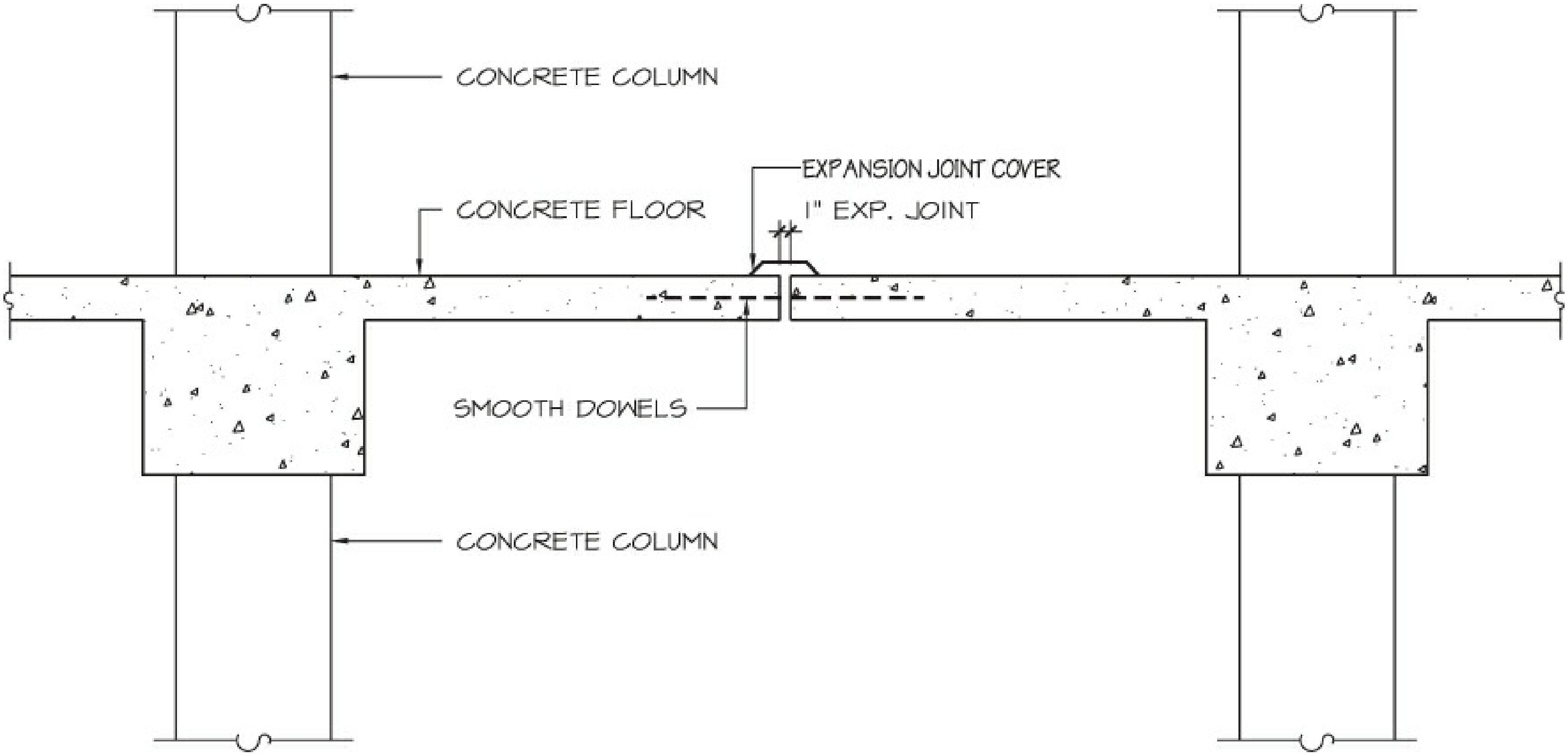
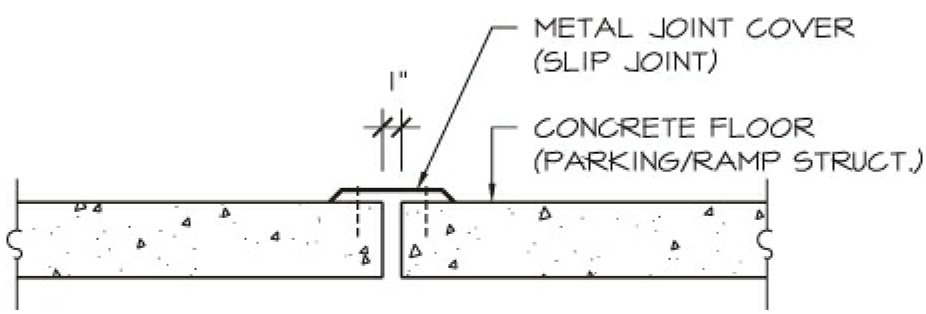


Figure 4.13 Expansion joint detail.

Another floor condition that may require an expansion joint appears when there is a large expanse of floor area, as shown in Figure 4.14. These expansion joints are placed in locations that are visually unobtrusive and will not require expensive covering methods. Concrete parking structures with vast areas of concrete floor require that various locations have expansion joints. The expansion joints are normally covered with an aluminum metal strip to allow easy passage of automobile traffic. These joints are referred to as **slip joints**. See Figure 4.15.



[Figure 4.14](#) Floor expansion joint.



[Figure 4.15](#) Expansion joint cover.

Underground Gas Control

Industrial and manufacturing buildings that are constructed on sites where there is evidence of underground gas, such as methane, will require a method of dissipating the underground gas. A recommended method is to install collector pipes below the concrete floor and vent these pipes to an outside area. [Figure 4.16](#) illustrates the partial foundation plan for an industrial building. It shows the recommended locations of 4″ "o" perforated pipes and reference detail symbols for the required pipe and venting installations. Note, in detail A, that a 24″ × 24″ gravel…filled trench encases the 4″ "o" perforated pipe as a means of collecting the gas. Detail B illustrates a method of venting the gas to the outside air through use of a 2½″ "o" vent in the exterior wall, terminating at a minimum distance of two feet above the roof.

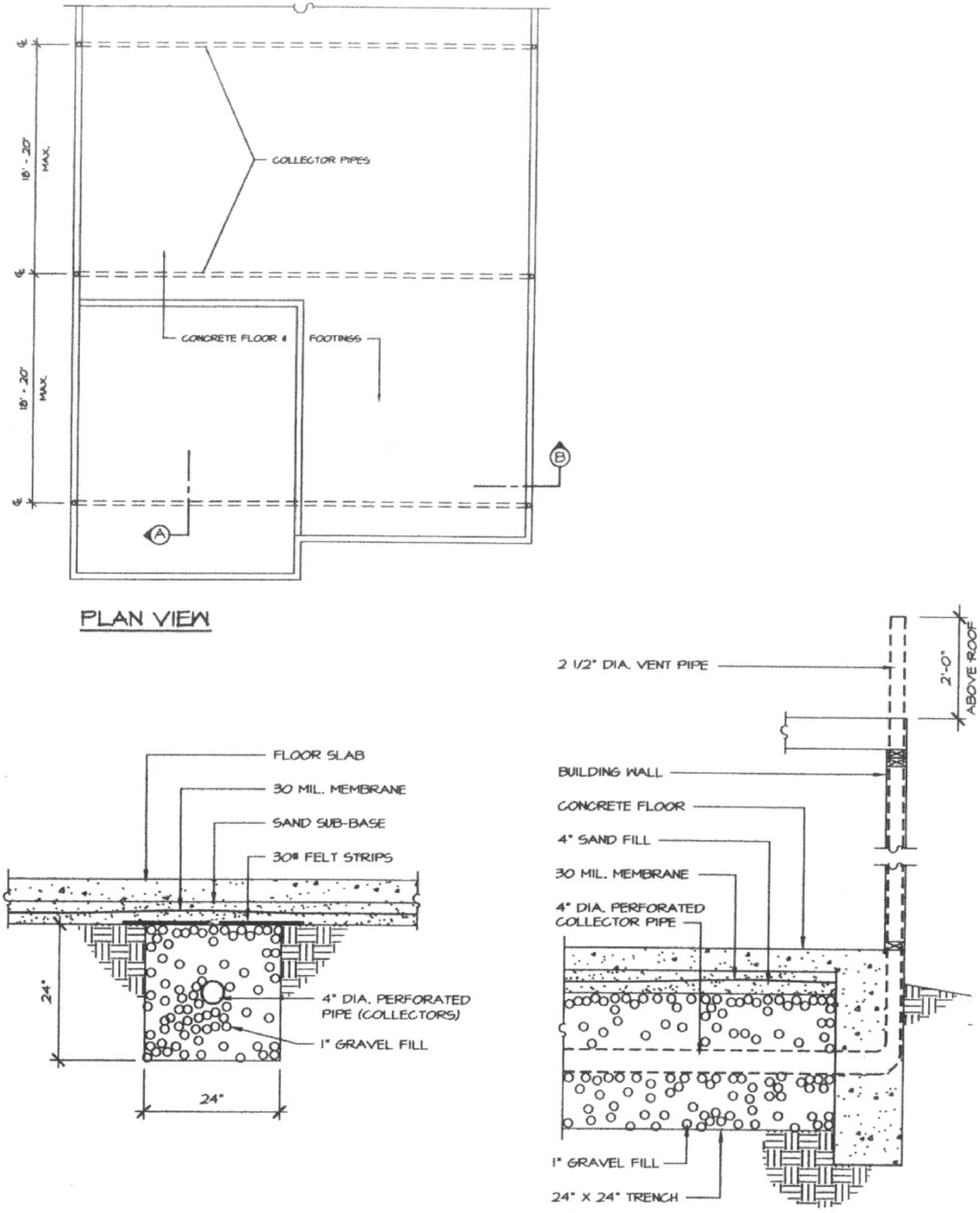


Figure 4.16 Partial building foundation plan.

Water Table

The term **water table** has two meanings. The first refers to the elevation (height) at which groundwater is atmospheric. The second refers to an aboveground projection that sheds water away from a structure. A sample detail of a water table at a foundation wall is shown in Figure 4.17.

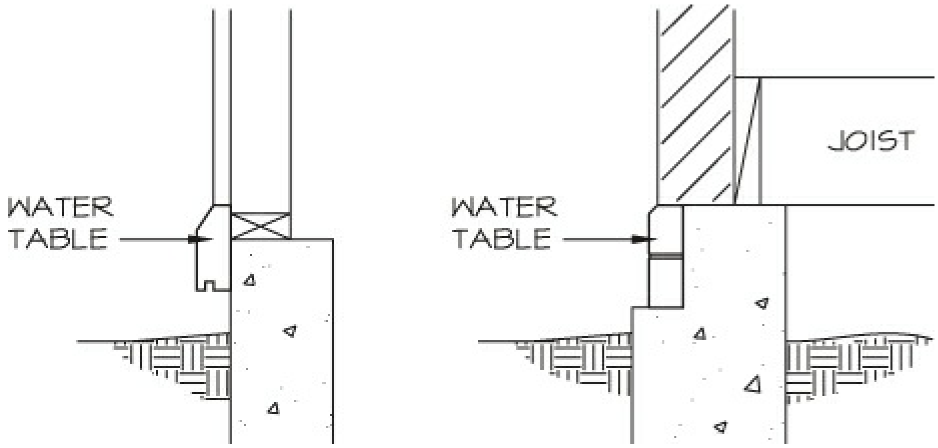


Figure 4.17 Water table at foundation plan.

First, let us establish some basic working facts about water, the movement of water, and water tables:

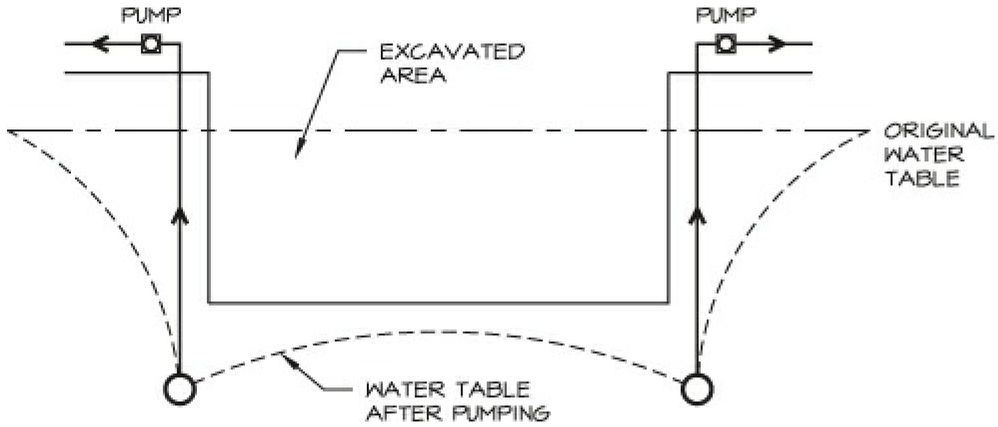
A. Water will pass easily through clean gravel and sand and seek its own level.

B. Perforated pipe in gravel provides an efficient means of travel for water. A good use for these pipes is under slabs and around basements.

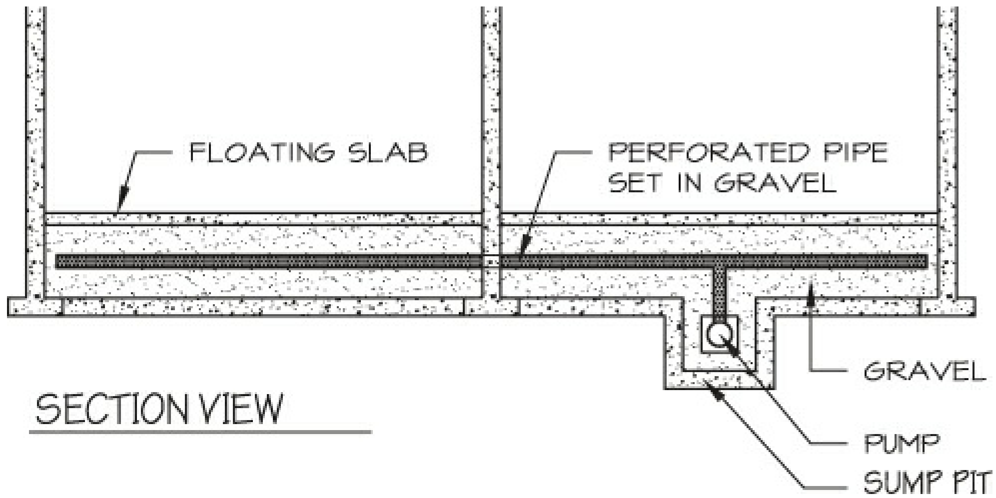
C. Water travels very slowly through silts and very little through clay. Thus, it is important to use gravel to encourage water to flow away from a structure.

D. There are two basic ways of keeping water from penetrating a substructure when the substructure is below the water table. The first is through waterproofing with a barrier and draining the water by way of a **sump pit** (a tank for holding water that is under grade until it is pumped out) and a pump. Note that waterproofing is not 100% effective.

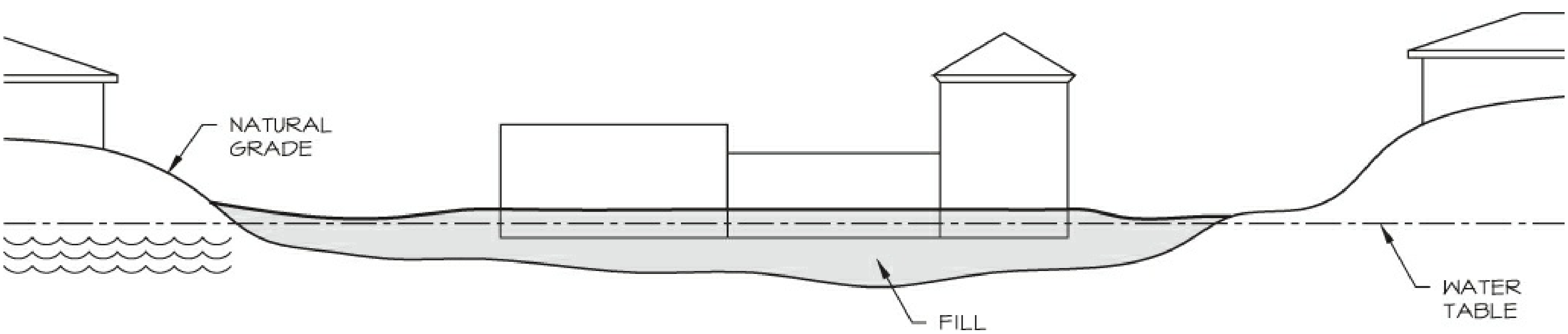
E. Municipalities require that when work is being done in an excavated area below the water table, the area must remain dry during construction. This can be accomplished with a pump or a series of pumps that change the water table configuration, as shown in Figure 4.18. An example of an area where this might occur is shown in Figure 4.19. Compacted fill is located in such a manner that the water table is just below the top of the fill. The foundation of a structure with such a fill will be built as shown in Figure 4.20.



[Figure 4.18](#) Diagram of dewatering.



[Figure 4.19](#) Removal of water table from substructure.



[Figure 4.20](#) Fill at water table.

Frost Line/Frost Depth

In many parts of the world, temperatures fall below freezing. Thus, a new level of measurement is introduced in reference to existing grade. This measurement, called the **frost line** or **frost depth**, is a significant datum for building (see Figure 4.21). These lines and numbers on the map represent levels below the grade under which water no longer freezes. This is important, because at these levels the moisture will not become a solid, expand, and cause damage to a foundation system. The figures given on this map are in inches and are for general use only. Frost lines should always be checked, because they are established by local code. The national code requires that a footing be placed a minimum of 1′…0″ below the frost line (see Figure 4.22). The ground will not freeze below

the frost line, making this a stable foundation.

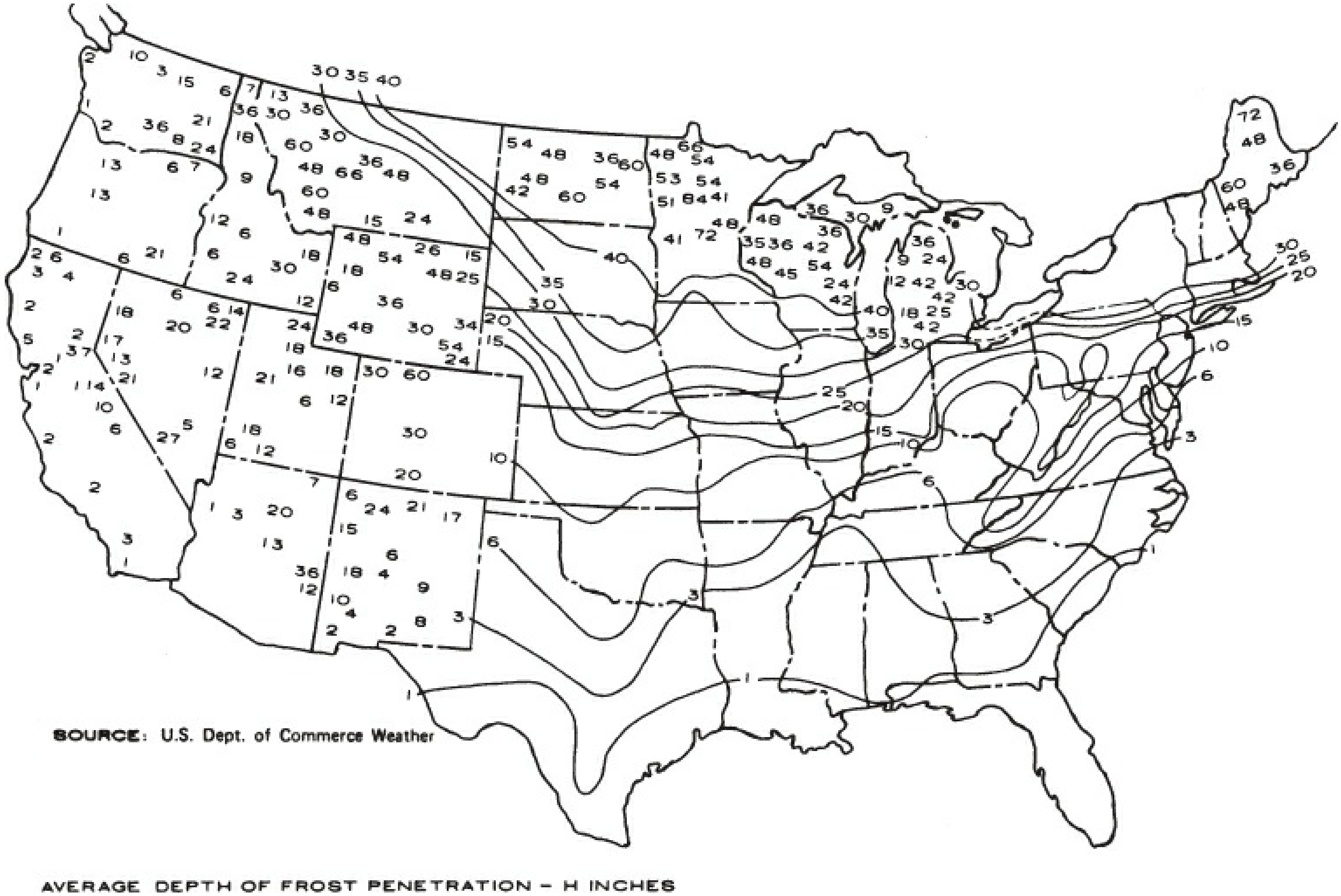


Figure 4.21 Frost depths.

(Reprinted by permission from *Architectural Graphic Standards,* 9th edition, © 1994 by John Wiley & Sons, Inc.)

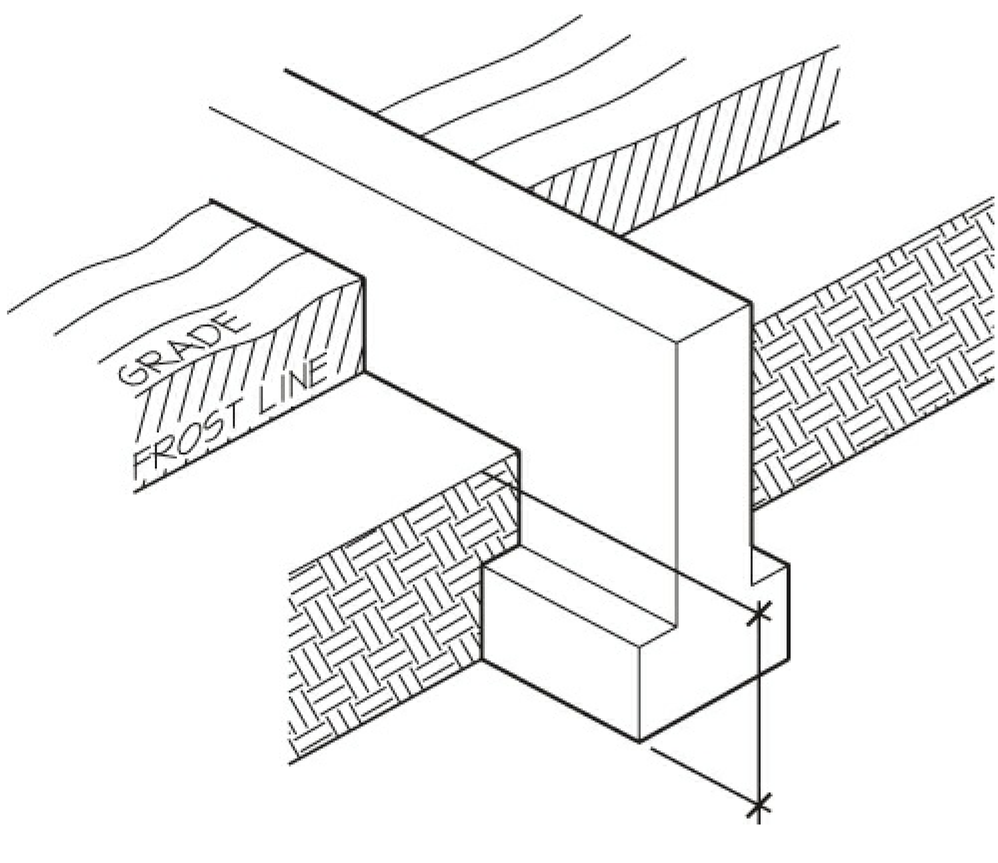


Figure 4.22 Frost line as a datum for footing depth.

To make us truly international and universal, rather than local or national, we must investigate cold climates in other parts of the world. There are climates such as these in the Arctic Circle, where we must deal with permafrost. We see this in one of the U.S. states, Alaska. The existence of permafrost means that the annual mean temperature is 32°F. These areas are also subject to very high winds, extremely cold temperatures, snow drifts, continuous dark days, and very low sun angles (vertical angle), in addition to permafrost.

How do we deal with this? We raise the floor level or build a gravel bed upon which the building sits. See Figure 4.23. Figure 4.23A shows how a building on permafrost is configured, and Figure 4.23B shows a building built where there is sporadic permafrost.

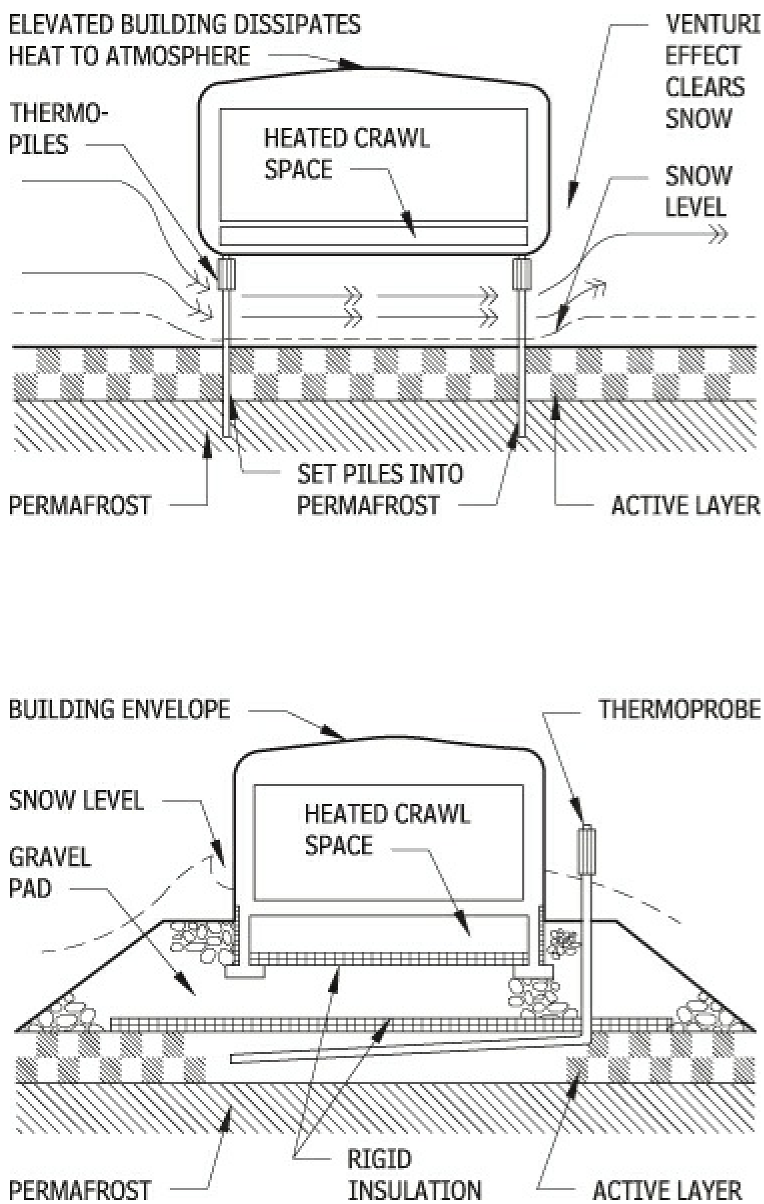


Figure 4.23 Building on permafrost.

(Architectural Graphic Standards CD..ROM, © 2000 by John Wiley & Sons Inc.)

Termites and Termite Treatment

The durability and longevity of wood are improved by preservative treatment techniques.

The treatment of wood is usually recommended for two reasons: (1) the location of a member subjects it to an unsafe amount of moisture content, especially where the climate or site conditions promote decay; and (2) termite infestation.

Termites are a major problem in some of our states. California, Hawaii, and the southeastern states are some of the most heavily infested areas. Although not everyone practices in an infested area, architects should be familiar with the methods used to deal with termite infestation. Figure 4.24 shows the distribution of termite infestation in the United States. The chart is calibrated in modest, moderate, and heavy infestation areas, and reveals that the areas most heavily affected are in our southern states.

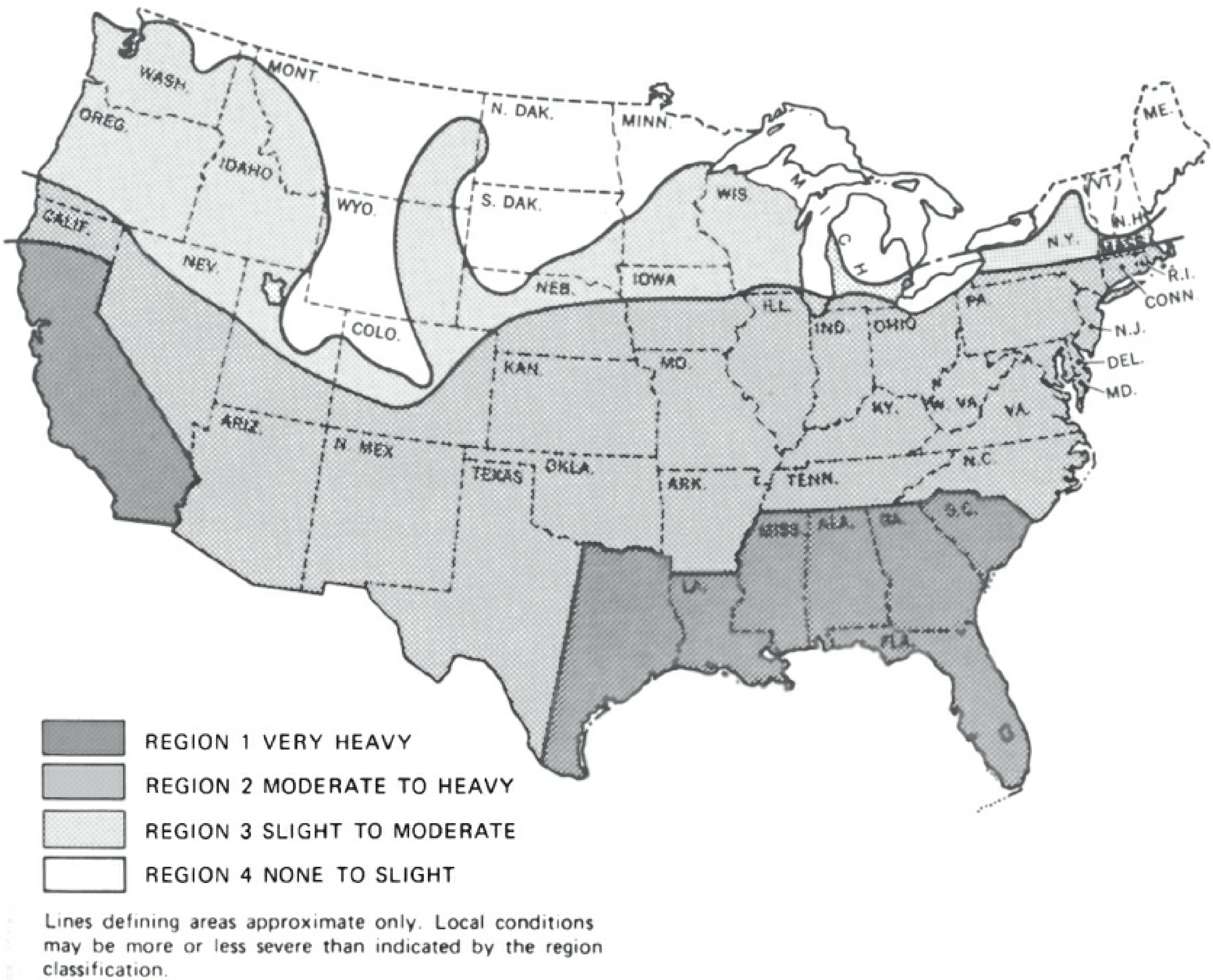


Figure 4.24 Regions of termite infestation.

(Reprinted by permission from *Architectural Graphic Standards,* 9th edition, © 1994 by John Wiley & Sons, Inc.)

When a structure is supported by wood members embedded in the ground, the members should be of an approved **pressure_treated (PT) wood**. PT wood is impregnated with toxic chemicals at elevated pressures and temperatures. One of the following classes of

preservatives is commonly used: (1) oil…borne preservatives, (2) water…borne preservatives, or (3) water…repellent preservatives. Code standards for preservatives and treatments should be in accordance with those of the American Wood Preservers Association. Water…borne or water…repellent preservatives should be specified when members are to be painted or when finish materials are to be nailed to the members.

Wood members, such as sills, ledgers, and sleepers, that come in contact with concrete or masonry that itself is in direct contact with earth should be of an approved treated wood and approved by the local building department.

The effectiveness of treated wood depends on several factors: (1) the type of chemical used, (2) the amount of treatment penetration, (3) the amount of treatment retention, and (4) uniform distribution of the preservative.

In the course of detailing, the architect should be cognizant of the application of treated wood. Examples of details incorporating a treated wood mudsill, ledger, and sleeper are illustrated in Figure 4.25.

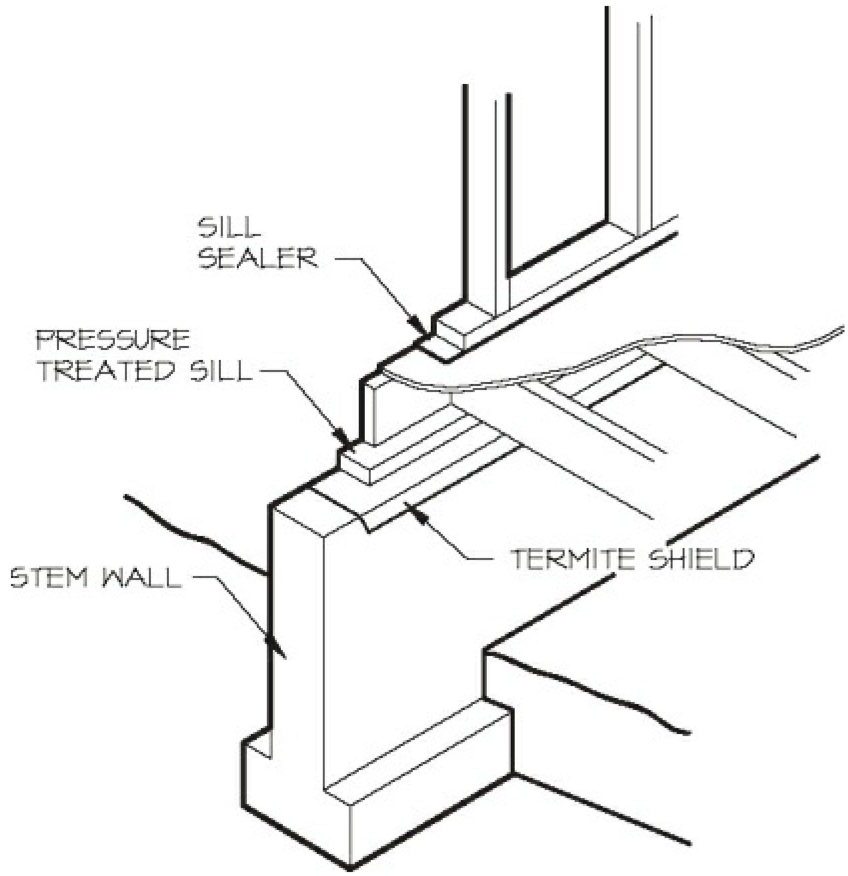


Figure 4.25 Mudsill area.

It should be emphasized that damage from moisture decay and termites develops slowly. Therefore, inspections should be done to ensure that proper clearances are being maintained and that termite barriers have been implemented and installed correctly. See Figure 4.26.

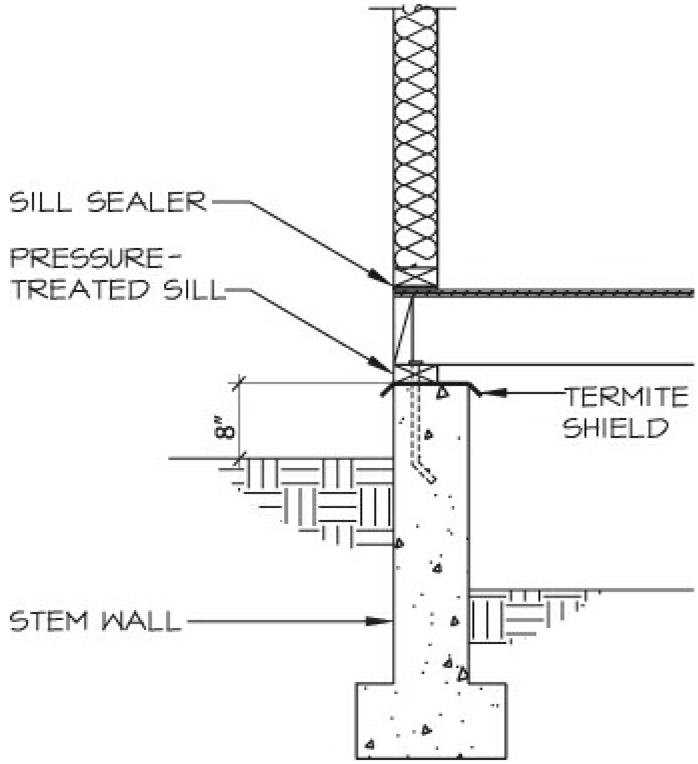


Figure 4.26 Detail of termite shield.

IMPACT OF MAN

Sound

Various types of unpleasant (negative) sounds can enter a structure and cause discomfort to the occupants. Aircraft, vehicles, and trains are some of the sources of sound that create a need to construct buildings that address the problems of sound infiltration. Figure 4.27 depicts some of the major contributors of negative sounds that will be confronted in the detailing and construction of a three…story building. The negative sounds coming from above a building, like those created by various aircraft, will necessitate full sound insulation in the roof and ceiling members and the use of sound…rated windows. For a detail of an insulated wall and ceiling assembly, see Figure 4.8. Sound infiltration through the exterior walls can be controlled through required sound insulation techniques. Insulation of an exterior wall is achieved either with full insulation placed inside the wall or with sheets applied to the outside of the wall. An example of insulated sheets applied to the outside of exterior walls is shown in Figure 4.28.

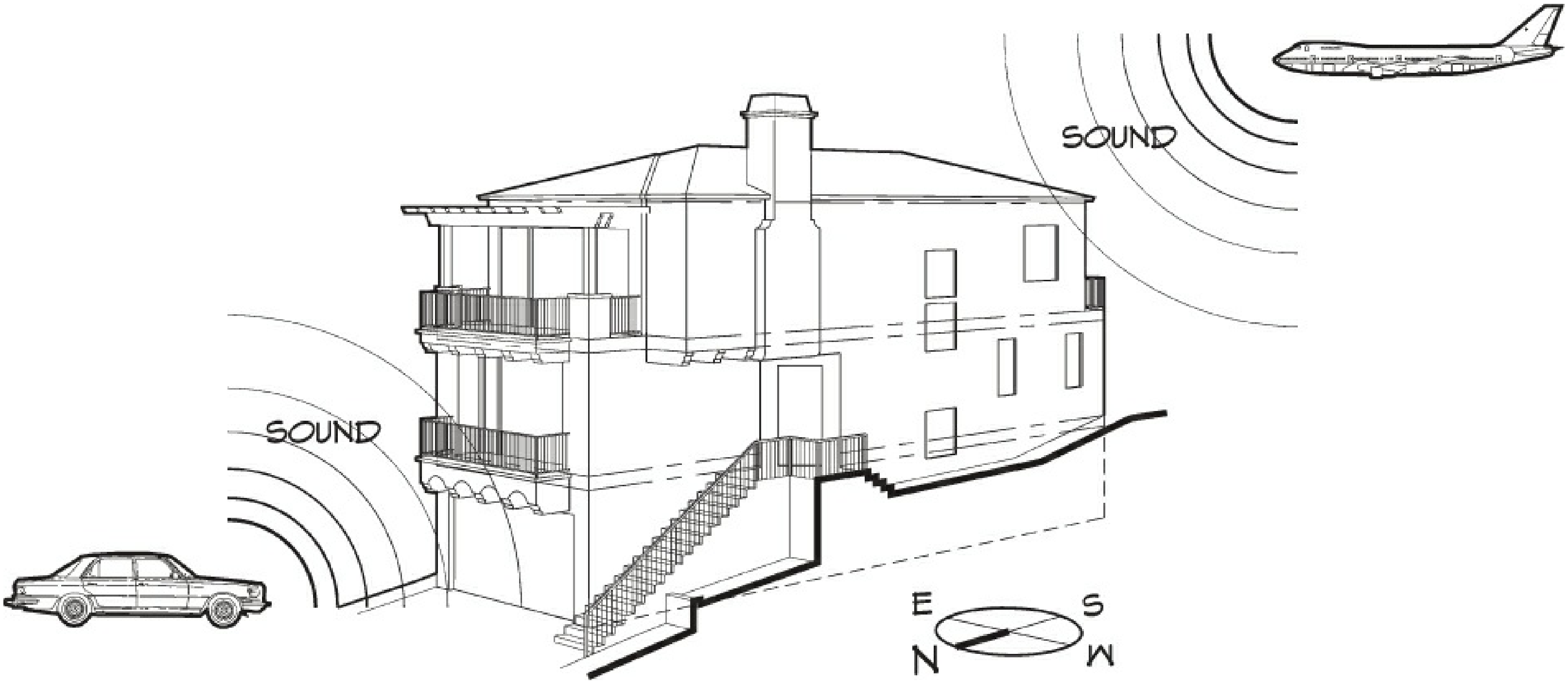


Figure 4.27 Sound‐producing forces.

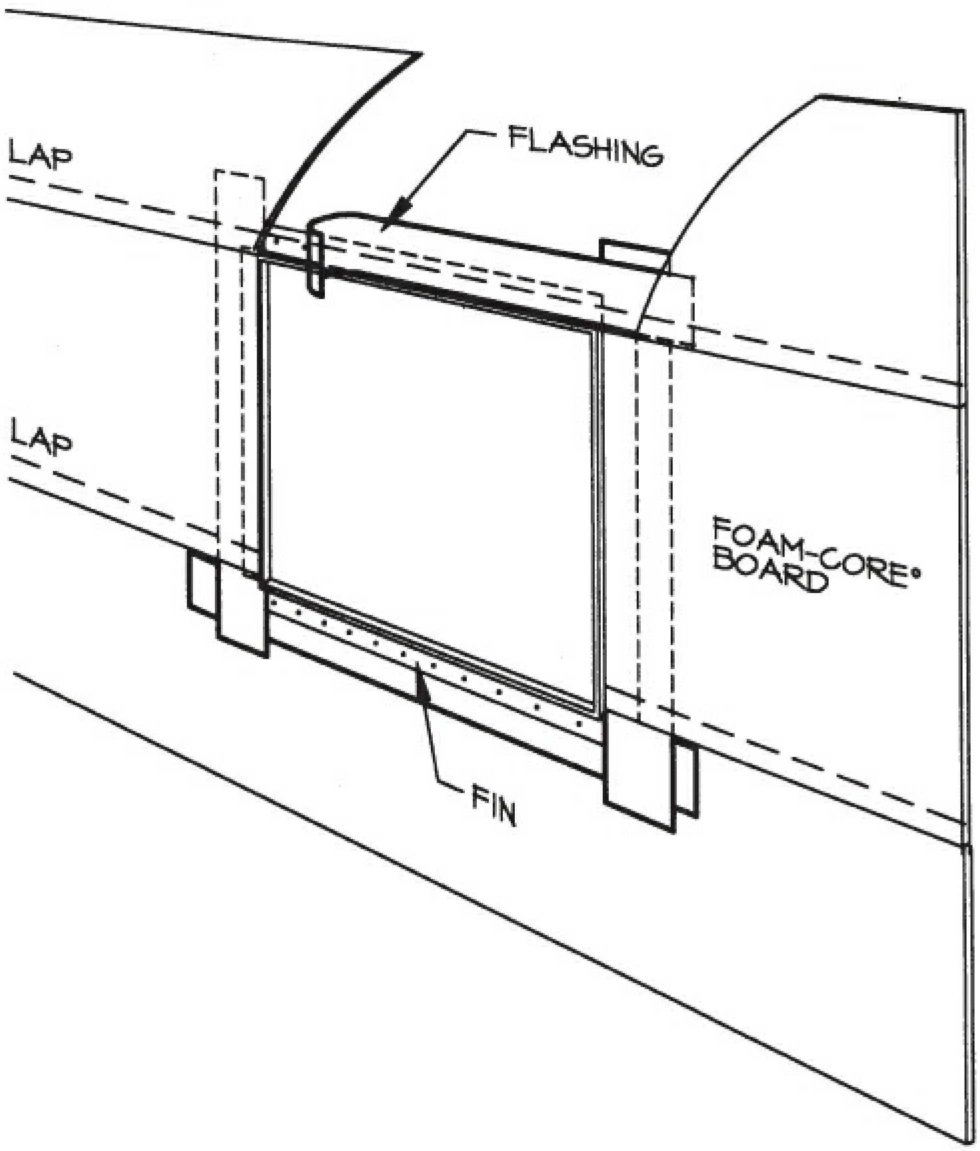


Figure 4.28 Fome‐Core® board as a wrap.

(Courtesy of International Paper. Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd

edition, © 1999 by John Wiley & Sons, Inc.)

In projects where concrete masonry units (CMUs) are used for the exterior walls, the open cells in the CMU may be filled with a metal baffle or a fibrous filler to deter or eliminate the infiltration of noise. A standard CMU with two types of insulation is depicted in Figure 4.29.

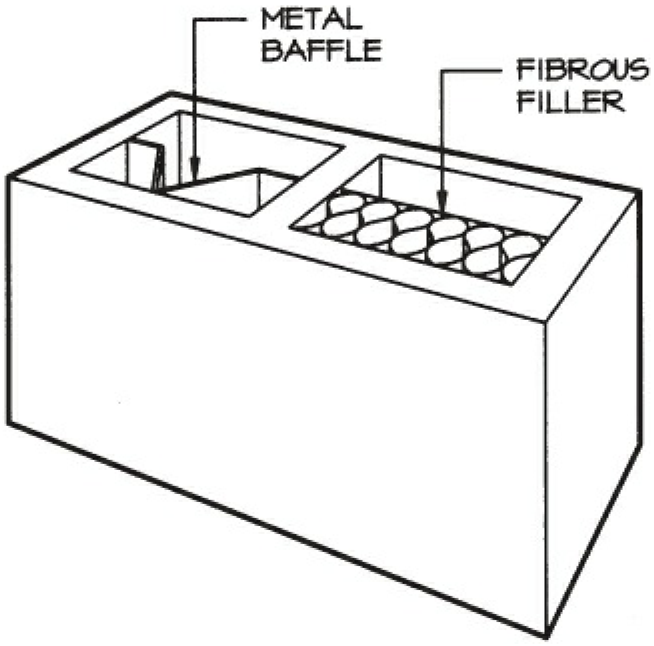


Figure 4.29 Sound insulation in concrete masonry units.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

An effective method of deterring noise transmission through a floor assembly is to use lightweight concrete, carpet, and pad and batt insulation between the floor joists. The finished ceiling below may contain two layers of 5/8″…thick gypsum board attached to resilient channels, which are in turn attached to the wood joists. The resilient channels will provide a vibration isolation separation between the wood joist, which transmits sound, and the living space below. See Figure 4.30.

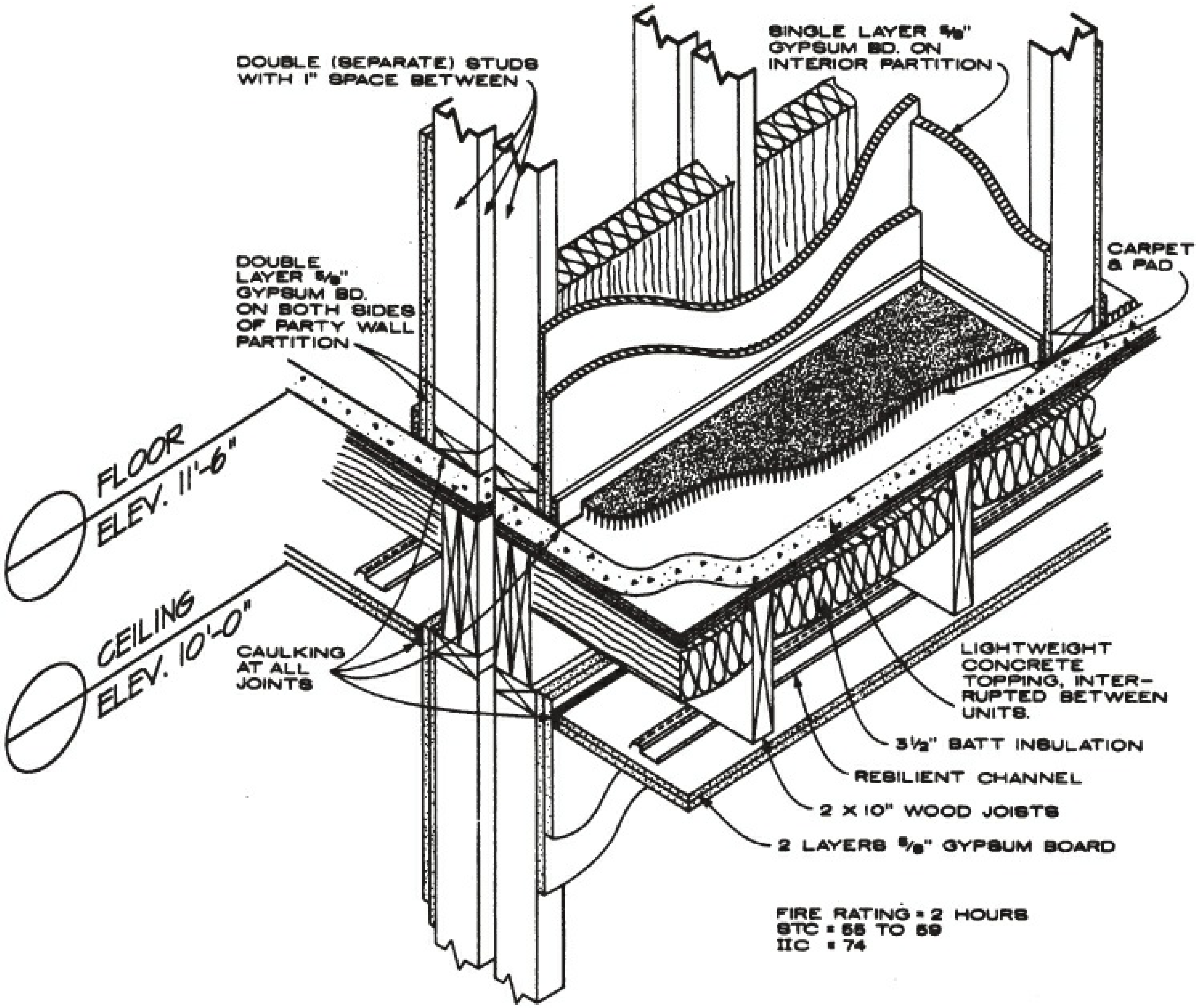


Figure 4.30 Soundproofing between floors.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

There are a few wood construction assemblies recommended for deterring sound transmission between the common walls of apartment units or other types of living units. One method is to provide a double…studded wall with a 1″ air space separating the individual stud walls, along with two layers of gypsum board on both sides of the party wall. Batt insulation is installed between the wood studs. See Figure 4.30.

Another method of interior wall insulation is to construct a wood wall with staggered studs and then continuously weave the sound insulation between the studs. The attachment of gypsum boards to the studs is accomplished with resilient clips. This construction method is shown pictorially in Figure 4.31. This type of assembly is less costly and slightly less effective than that shown in Figure 4.30.

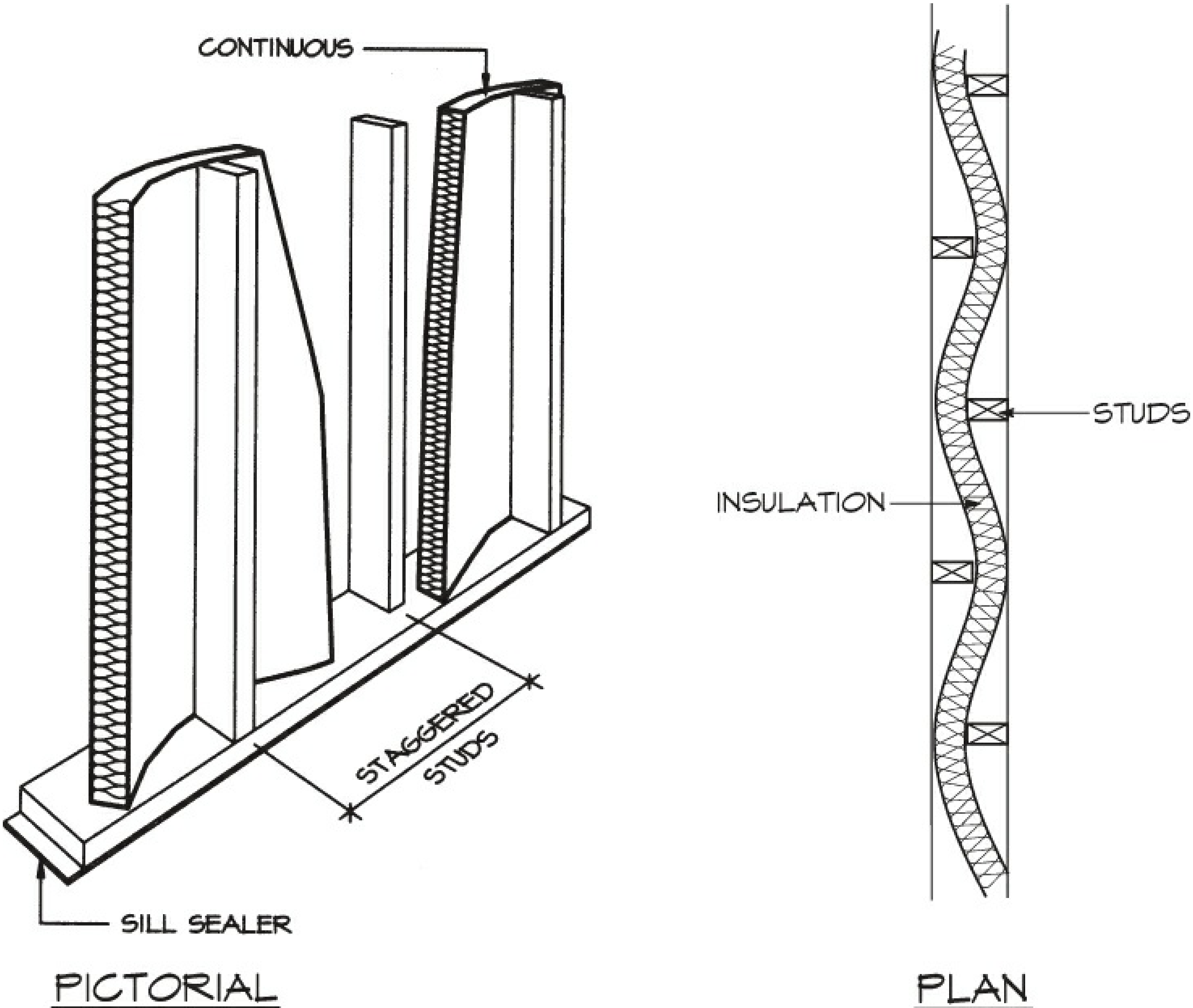


Figure 4.31 Interior wall sound insulation.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

An alternative method for deterring sound transmission through a floor assembly is to have a separate ceiling independent from the floor joist above. This will necessitate separate ceiling joist members with a higher wall plate line to support the floor joist above. The space between the floor joist and the ceiling joist is an ideal arrangement for preventing sound transmission as well as allowing space for plumbing lines, heating ducts, and other equipment requirements. Resilient channels are recommended for the attachment of the gypsum board to the ceiling joist. This detailed assembly is illustrated in Figure 4.32. A drawing depicting this assembly is shown in Figure 4.33.

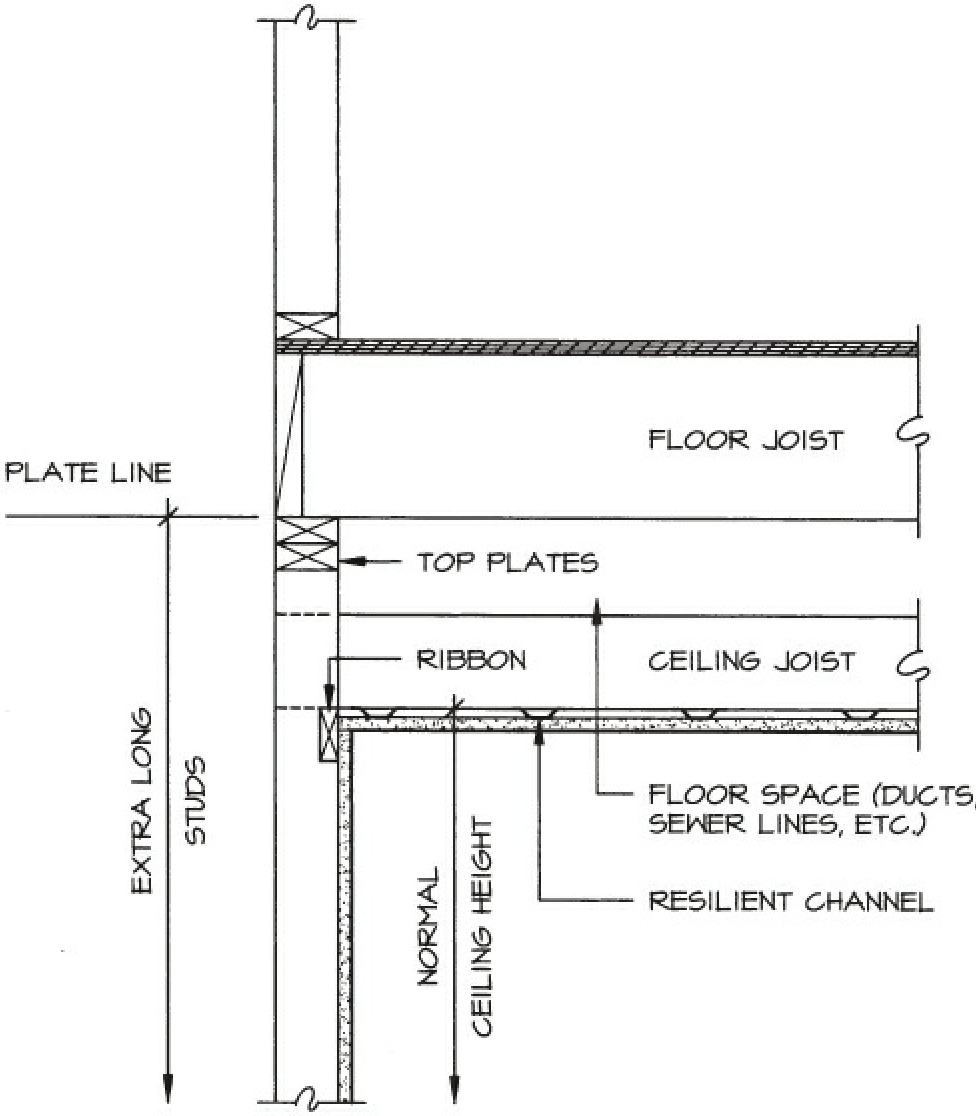


Figure 4.32 Detail of floor…ceiling separation.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

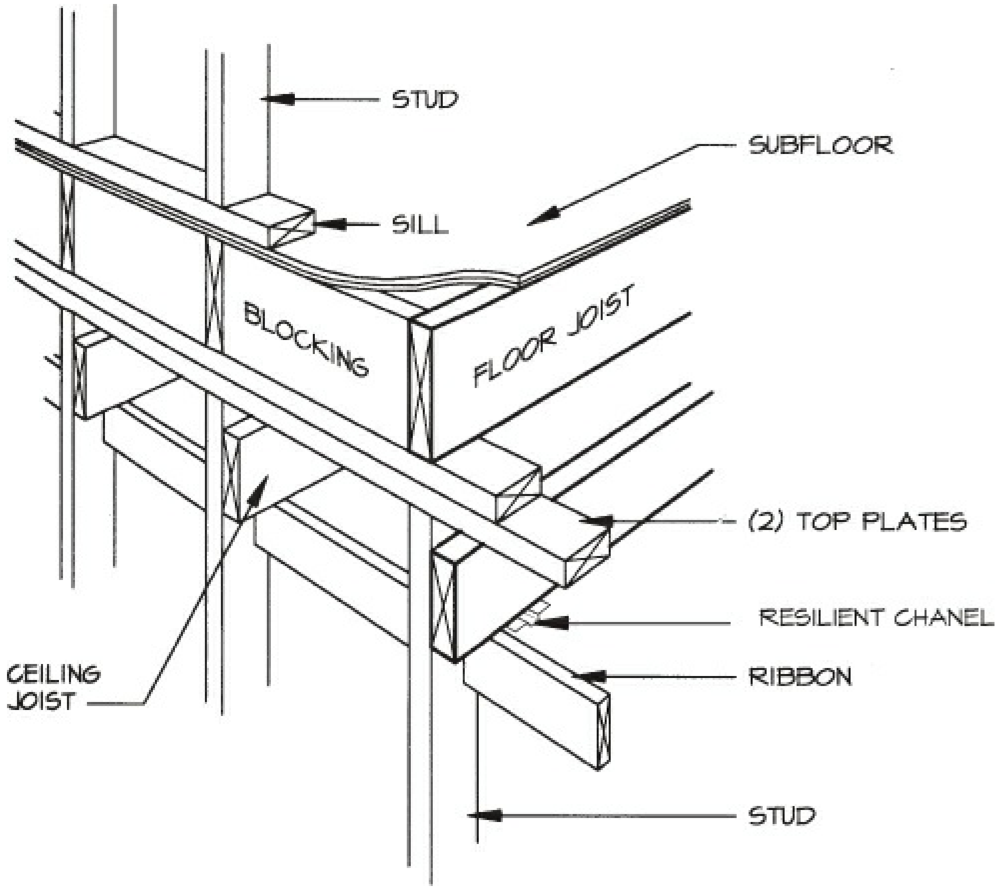


Figure 4.33 Separation of floor joist and ceiling joist.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

Fire and Smoke

Fire and smoke are major concerns in the design of all types of structures. Building fires may be ignited by both external and internal causes, ranging from brush or forest fires to various internal causes, including electrical, vehicular, or heating fires.

Fire. Various methods and procedures are used to prevent the destruction of a building by fire. One method is to protect the various materials used in construction of the building. Underwriters Laboratory (UL) conditions, various materials or a combination of materials are tested and given fire rating designations. These fire ratings are expressed as the number of minutes and hours it takes a material to catch fire. For example, a wall may be fire rated as a two…hour firewall, or a specific door may have a rating of 60 minutes. Structural columns can be assembled to provide a four…hour fire rating, whereas a glass panel may be manufactured with a 20…minute fire rating. Laboratory testing has produced results in a time/temperature chart illustrating temperature in degrees and time in hours.

Figure 4.34 is a chart showing temperatures measured in degrees Fahrenheit (°F) and Celsius (°C) as they relate to a particular length of time measured in hours. An example, using this chart, is a one…hour fire rating for a material or combination of materials that would withstand a fire with a temperature of 1500°F or 860°C.

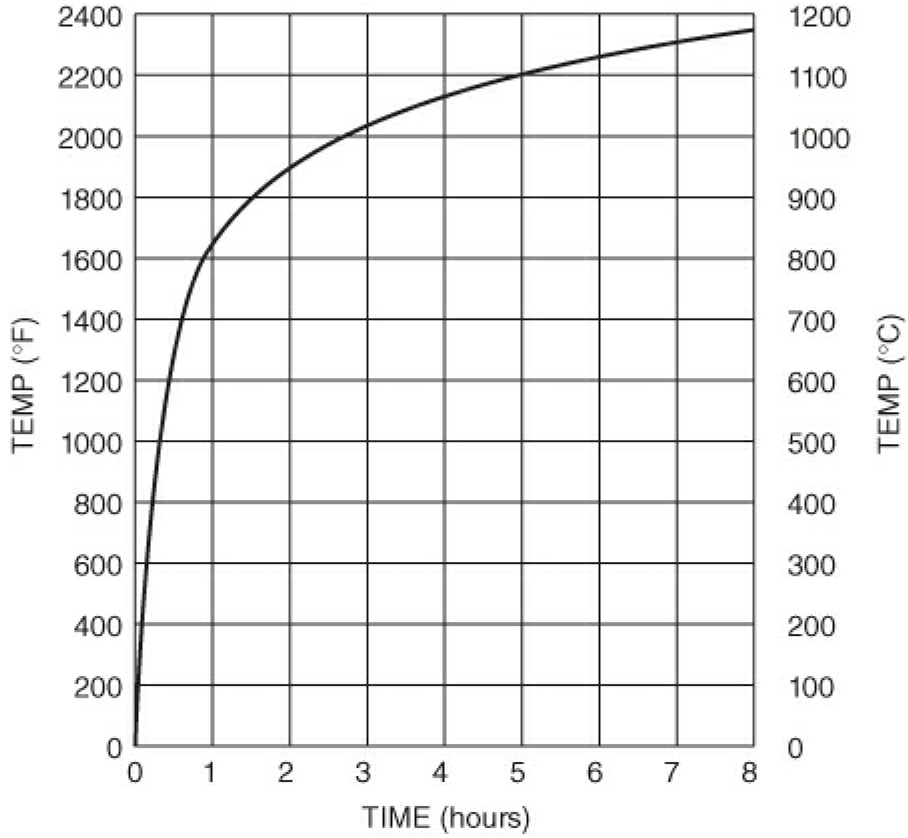


Figure 4.34 Time/temperature curve.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

Although all parts of a structure are vulnerable to fire, the safety of the occupants and the integrity of the structure can be enhanced by providing construction details that incorporate fire‐rated materials to deter a fire or to minimize the spread of a fire. Buildings in high‐risk brush fire areas can use exterior materials that will withstand high temperatures. This will give the building's occupants a longer time to evacuate the building in the event of a fire. For example, a cement tile roofing material can be used for brush fire protection in a single‐family residence. The construction detail of the eave and soffit assembly for such a single‐family residence is depicted in Figure 4.35 with a reference detail bubble “B” of the construction. Using a nonflammable roof material, the soffit detail is enclosed with a 1″‐thick cement plaster finish that will deter a fire from spreading into the attic spaces. This is illustrated in detail and pictorial form in Figure 4.36. Note that fireblocking is installed below the soffit area to deter any fire that may occur in the exterior wall. To complete a fire‐protective envelope of the exterior materials, this residence has a wood‐sided exterior wall finish. There is a layer of one‐hour‐rated fire‐resistant hardboard and fire taping at all the joints of the hardboard. This is installed prior to installation of the wood siding. A detail and a pictorial drawing are shown in Figure 4.37.

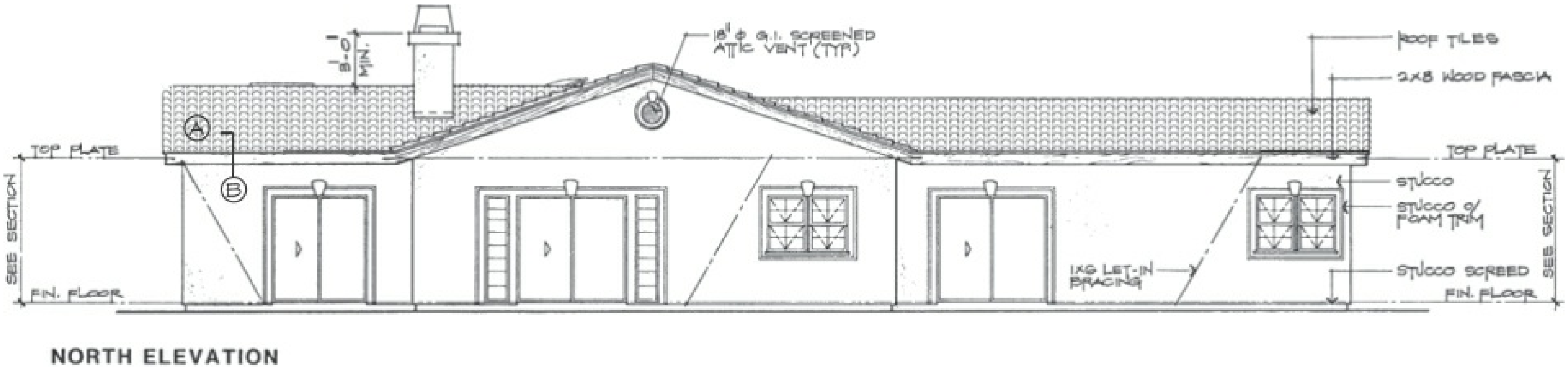


Figure 4.35 Exterior elevation—external fire control.

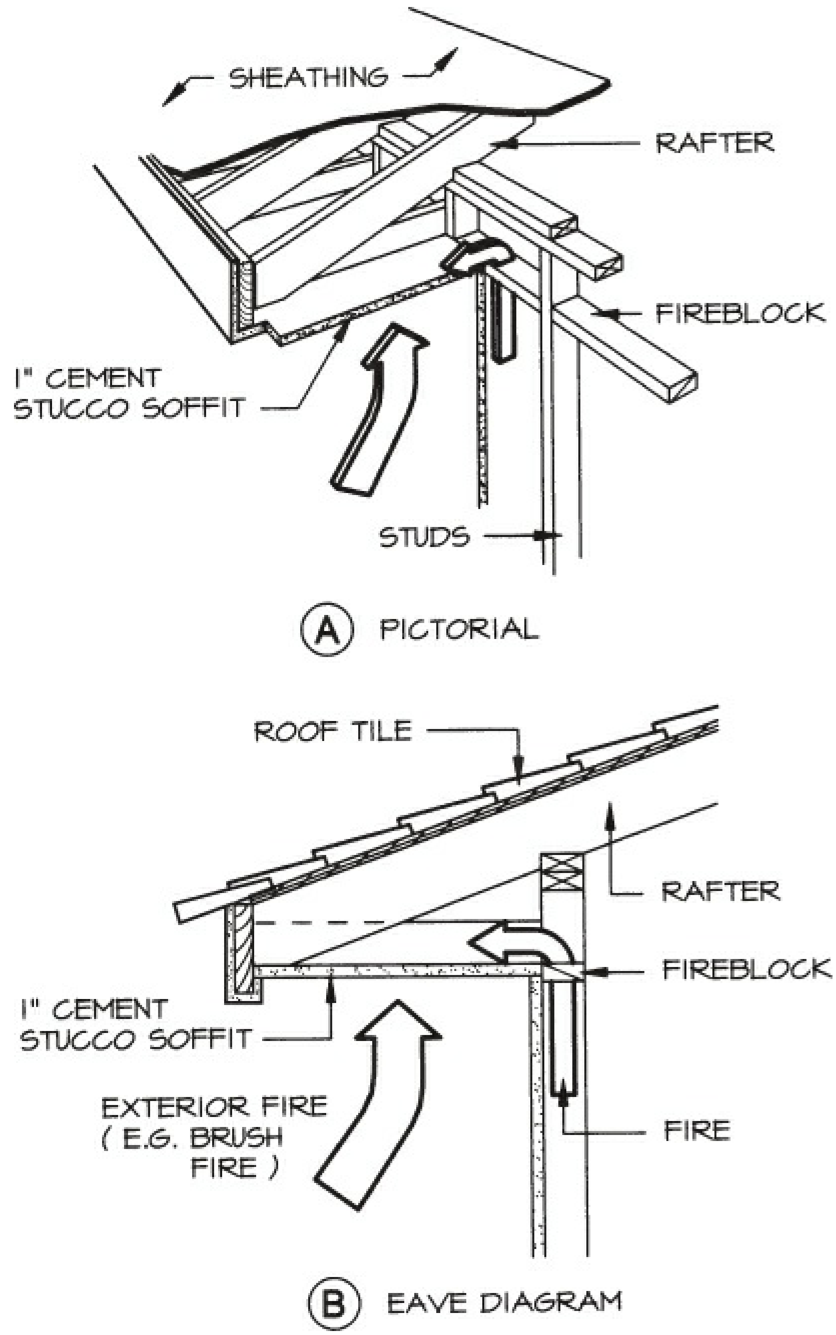


Figure 4.36 Roof tiles, cement stucco soffits, and fireblocking.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

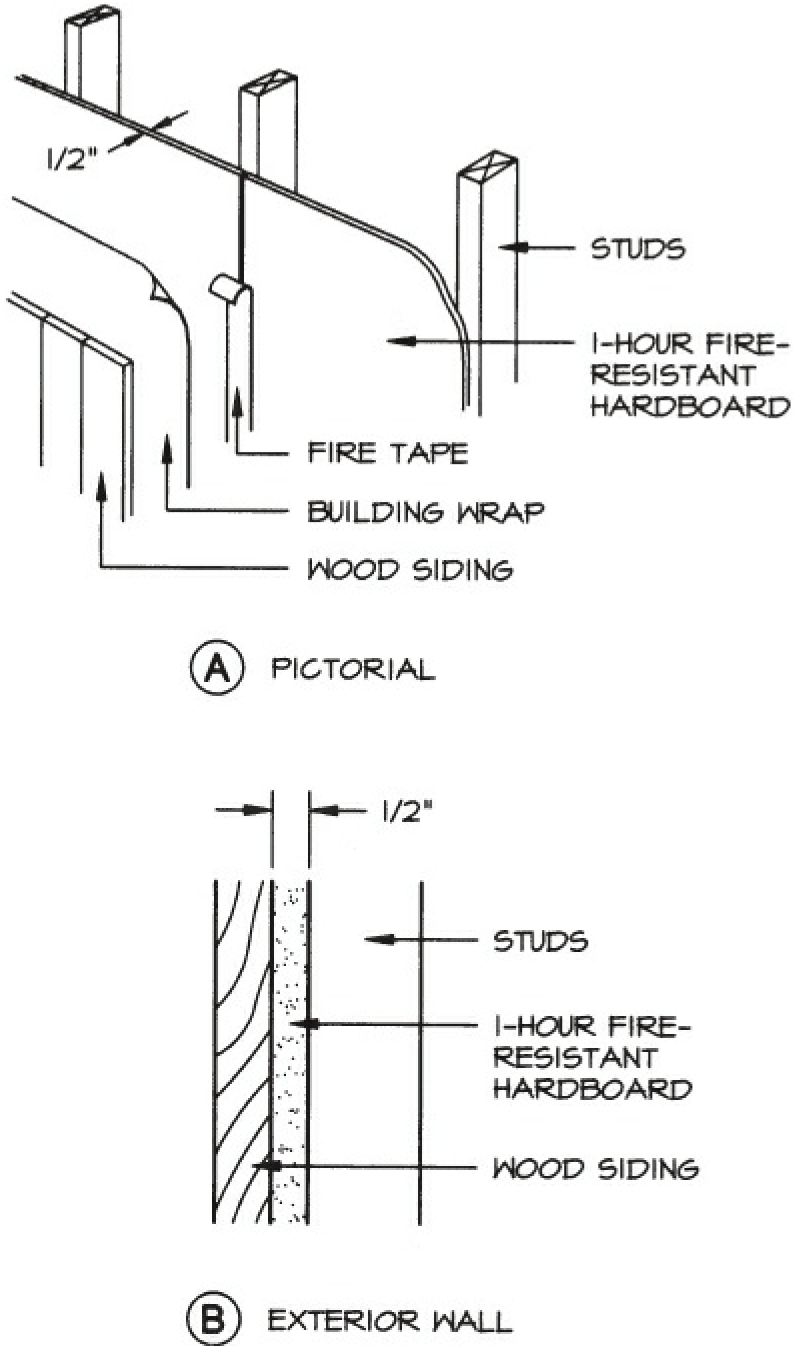


Figure 4.37 Fire‐resistant stud walls.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, ©1999 by John Wiley & Sons, Inc.)

Smoke infiltration is a grave concern because most “fire” deaths are actually caused by the smoke rather than the flames or heat. Detailing the openings in walls, such as those for doors and windows, will reduce the potential of smoke infiltration. One means of reducing the infiltration of smoke through doors is to mill the head and jamb sections and the doorstop from one piece of wood. This feature is required by most building codes and fire protection agencies. A detail of a jamb and head section for a door assembly incorporating a one‐piece section is illustrated in detail and pictorial form in Figure 4.38.

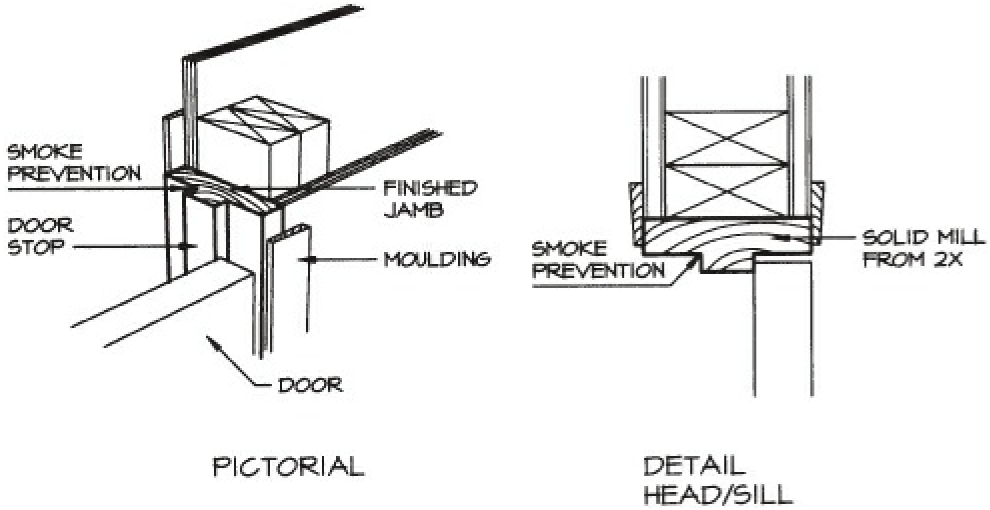


Figure 4.38 Solid…finish jamb and doorstop.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

Another concern in regard to fire is a building's stairs and exits. During the planning of a building, the architect must provide clearly defined pathways to fire exits. Fire exits and their layouts are determined by the governing fire protection agency and the requirements of applicable building codes. Distances between stair exits and the number of exits are also established by the governing agencies. In multilevel buildings, a correct stairwell design will allow people to move quickly down the stairs to an outdoor access without any interferences or obstructions in the exiting path.

A typical requirement for distance between stairwells is that it must exceed half the distance of the diagonal measure of the building. The local building code establishes requirements for the construction of the stairway walls. The stair tower is typically a fire…rated assembly. An example of a wood…constructed two…hour firewall assembly detail is illustrated in Figure 4.39; in this example, a two…hour wall construction encloses the stairwell.

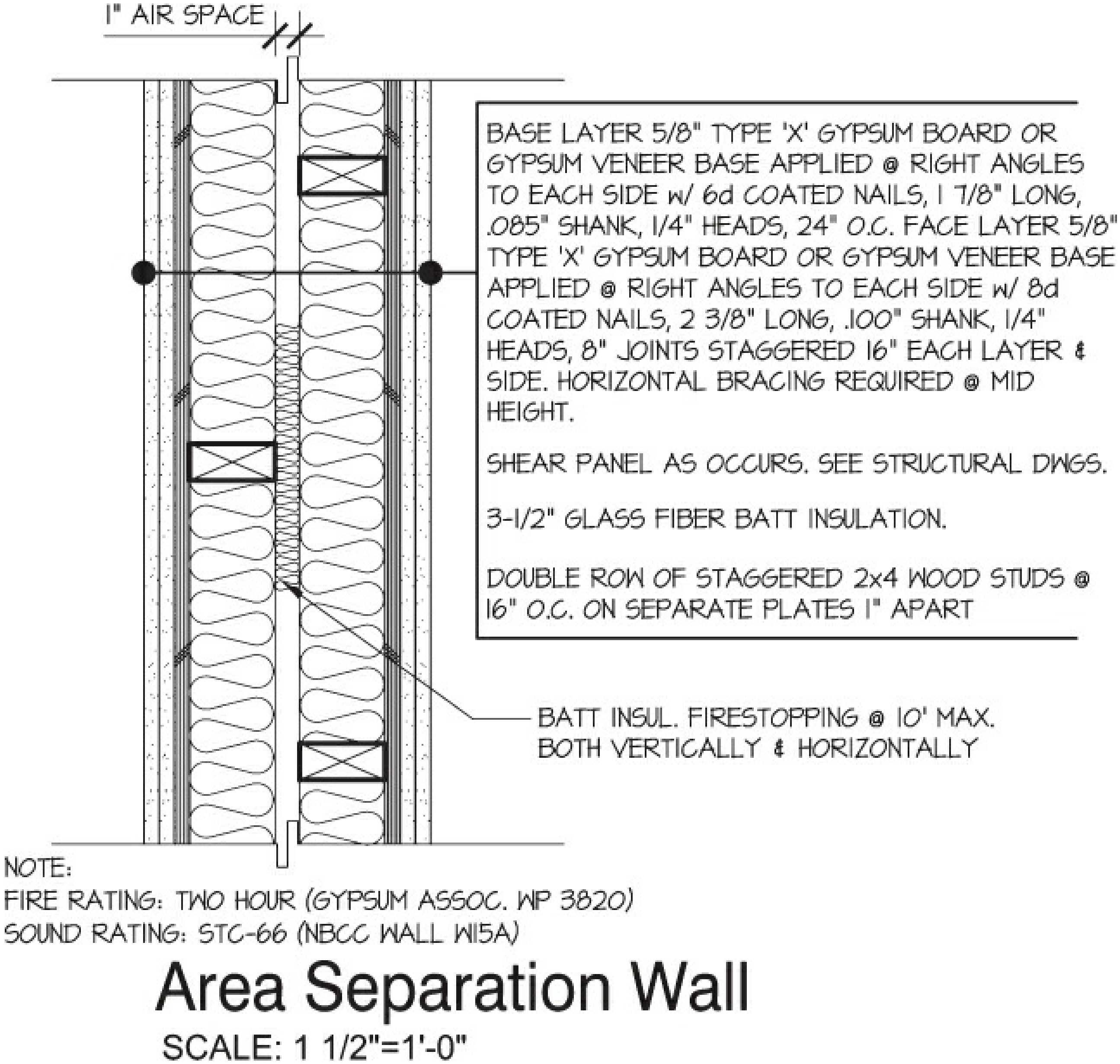


Figure 4.39 Two…hour area separation wall detail.

All fire…rated doors must swing in the direction of the exit access. Note, too, in this example, the required two…hour wall construction that encloses the stairwell. The local building code establishes requirements for the construction of the stairway walls. An example of a pictorial view of a wood…constructed, two…hour, firewall assembly detail is illustrated in Figure 4.40.

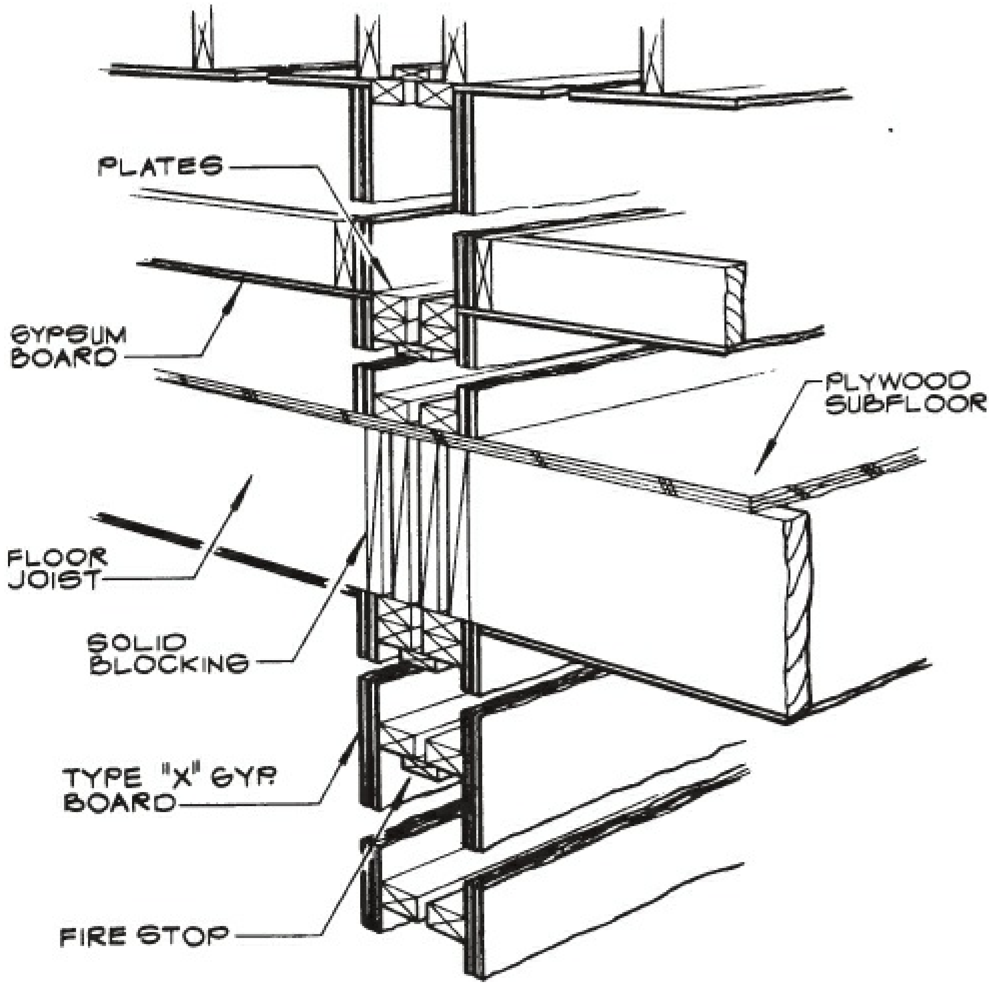


Figure 4.40 Pictorial view, two…hour area separation wall.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

Smoke. The exhausting of smoke is a major concern in fires that occur in buildings. It has been determined that smoke kills more people in building fires than heat itself, flames, or structural failure. Therefore, smoke control, whether through deterring smoke infiltration, as previously discussed, or by exhausting smoke from within the structure, is important. A common method for exhausting smoke from a building that is on fire is to use automatic roof hatch ventilators. These automatic ventilators, which are usually found in smaller buildings, open individually by means of a device that is activated by either smoke or heat. An example of a roof hatch ventilator that may be installed on a one…story industrial building is illustrated in Figure 4.41. The sizes and locations of these ventilators are determined by the governing fire protection agency and the building code.

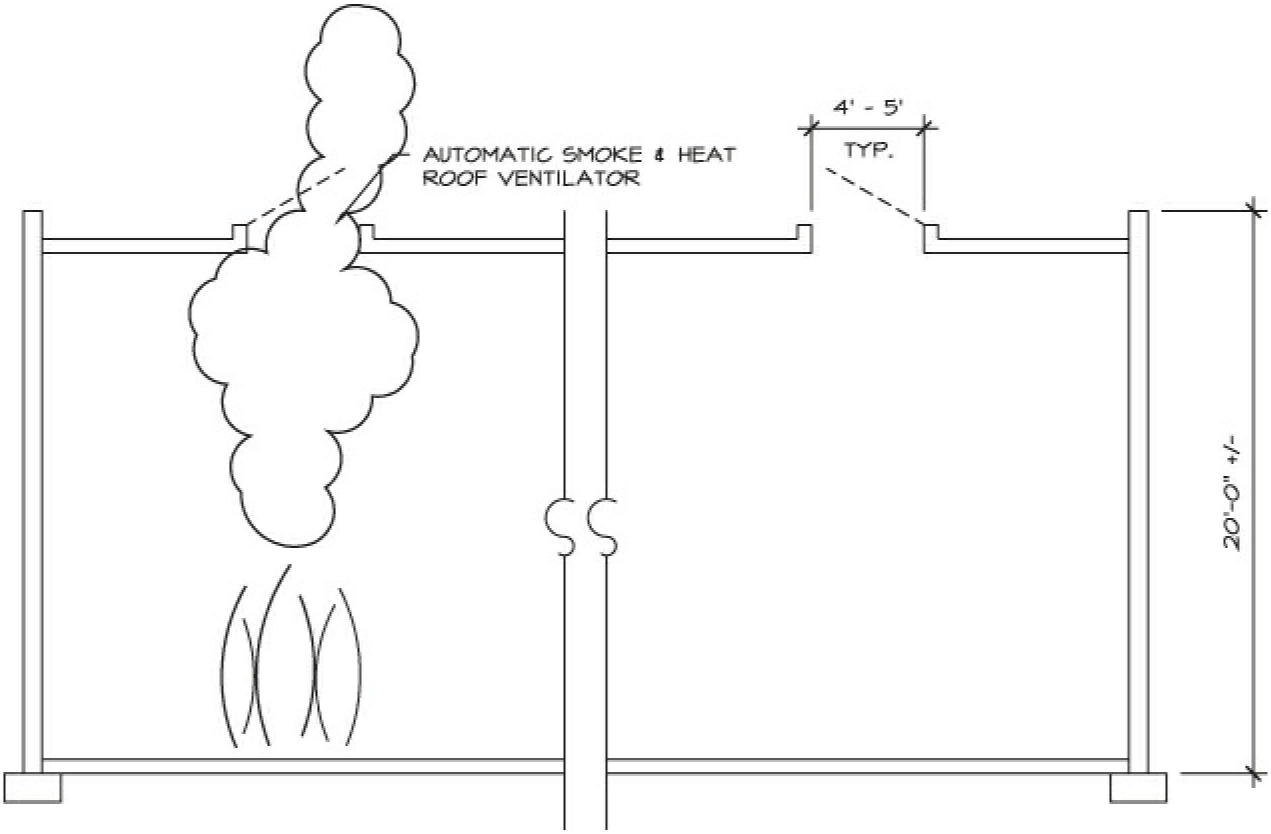


Figure 4.41 Smoke and heat roof ventilators.

Concerning fire and smoke as they relate to the design of a structure, the architect should be aware of the following:

1. How occupants exit a building in fire and smoke conditions
2. Fire ratings of materials and code requirements
3. Methods of preventing smoke infiltration and the spread of fire
4. Vulnerable areas within a structure
5. Methods of reducing the spread of fire
6. How to protect the integrity of the structural members from fire
7. Methods of exhausting smoke to the outside (the major concern)

Deterioration

Many steps are taken in detailing the methods used to reduce or eliminate deterioration of the various building materials in a structure. As we have seen, the use of metal flashing for foundation details, roof conditions, and other features provides wood with some protection from deterioration. However, other conditions can also subject wood to deterioration.

For example, future deterioration is a great concern where there are wood posts on concrete porches. Water from rain or hose streams and sprays is a great catalyst for deterioration at the base of a wood post. One method for detailing this connection to prevent deterioration at the base of the post is to elevate the post base above the concrete

patio. See Figure 4.42. As shown, a galvanized metal or aluminum prefabricated base is positioned under the post to provide a 1″ clearance above the concrete patio. Openings in the metal base unit will provide for water drainage.

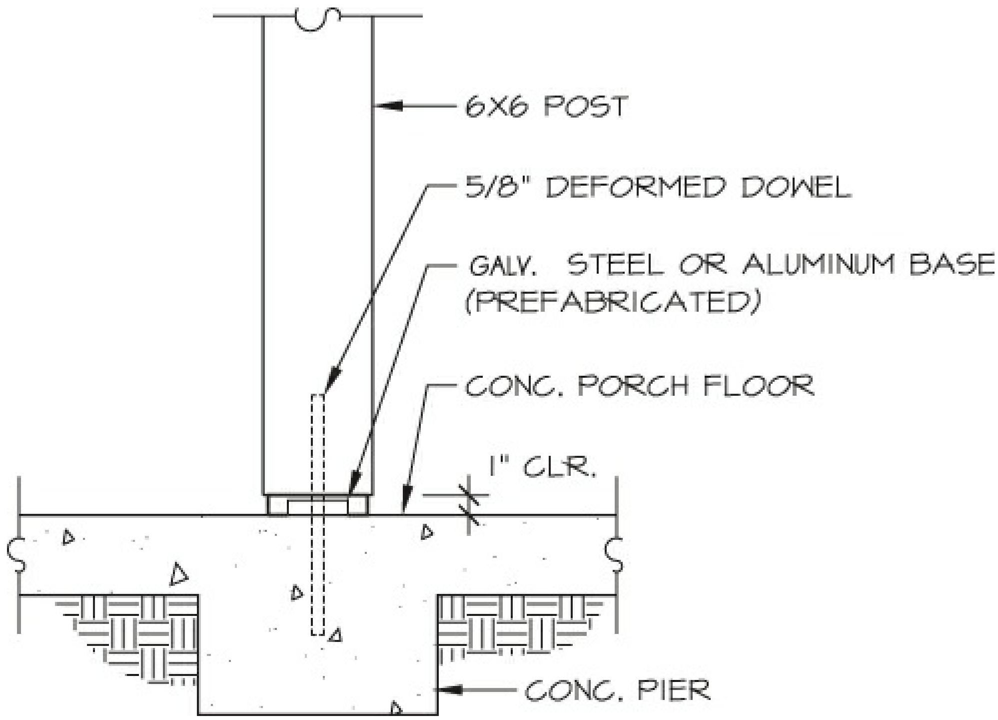


Figure 4.42 Elevated porch post.

Methods of anchoring exterior wood posts that may be used for fences, balustrades, and wood trellises vary as to how they may be detailed. Figure 4.43 depicts an example of detailing the anchorage of a wooden fence post. This is recommended because the wood post is elevated above the soil and is protected from both soil and water by the concrete pier. Anchorage of the wood post to the concrete pier is achieved by using a manufactured or prefabricated galvanized steel “U” strap and machine bolts. The sloping top perimeter of the concrete pier prevents water from collecting at the base of the post and metal strap.

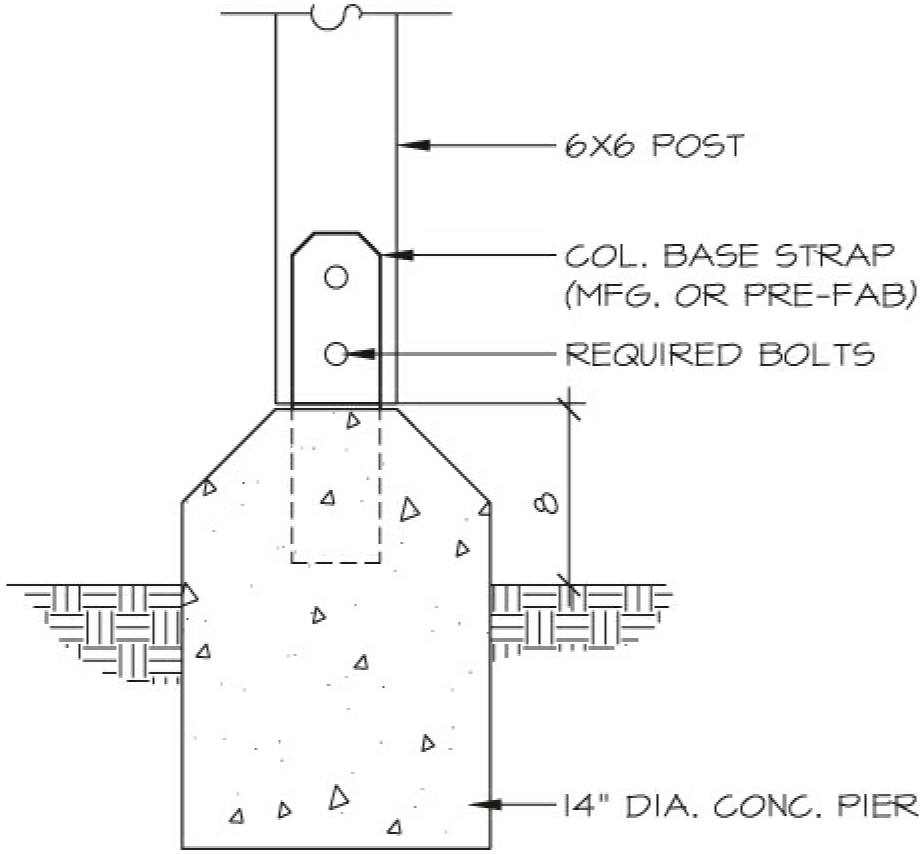


Figure 4.43 Wood post/pier assemblies.

Drainage/Rainfall

The accumulation of rainwater may lead to erosion or flooding problems. Because all regions of the country have specific and particular climatic conditions relative to the amounts of rainfall, the architect will need to anticipate and solve any problems of water drainage that may affect a building's structural areas and site conditions. As a general rule, water must drain away from the building to appropriate drainage devices or catch basins.

Roof Drainage

Roof designs and drainage devices are designed and detailed to dissipate and control rainwater. For example, a very low…pitched roof design will create a slower flow of water runoff, which may reduce the possibility of flooding around a building's foundation. Devices such as code…acceptable manufactured roof drain units or conventional gutters and downspouts should be placed in key locations on the roof to accommodate and control any amount of rainwater. An example of a roof drain is shown in Figure 4.44. Note that an overflow drain is incorporated as a safety measure in case there is blockage in the roof drain. Blockage may be a result of tree leaves, debris, and the like. The solutions for exterior deck drainage are similar to those recommended for a roof drainage system.

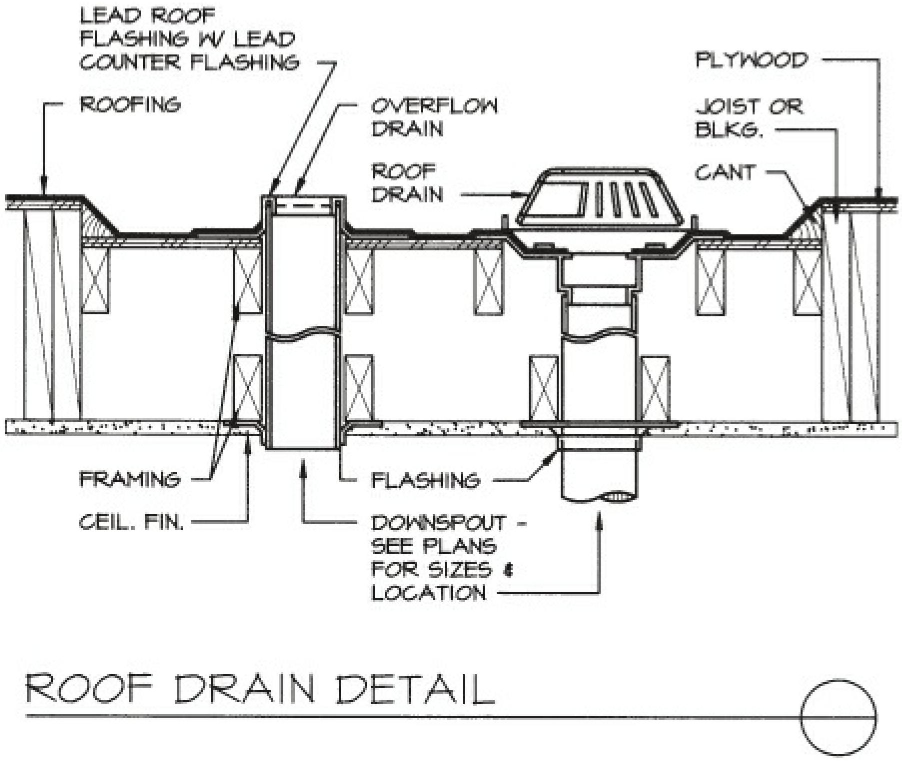


Figure 4.44 Roof drain section.

(Reprinted by permission from *Professional Practice of Architectural Detailing,* 3rd edition, © 1999 by John Wiley & Sons, Inc.)

Roof drainage that is conducted to the roof eaves or overhangs is detailed in various ways. A recommended method of detailing an eave for dispersing water from the roof areas is to provide a gutter and downspouts. This method will control and direct the water to areas that will disperse the water away from the building, thus deterring erosion at the perimeter of the building. The concentration of water caused by the downspouts can be quickly dissipated with use of a splash block. Another method of dispersing the water flow concentrated at the eave, in lieu of metal downspouts, is to attach a steel or aluminum chain from the roof gutter to a concrete splash block. The shape of the chain will act to slow the water flow and further limit the possibility of erosion. These detailed conditions are depicted in Figure 4.45.

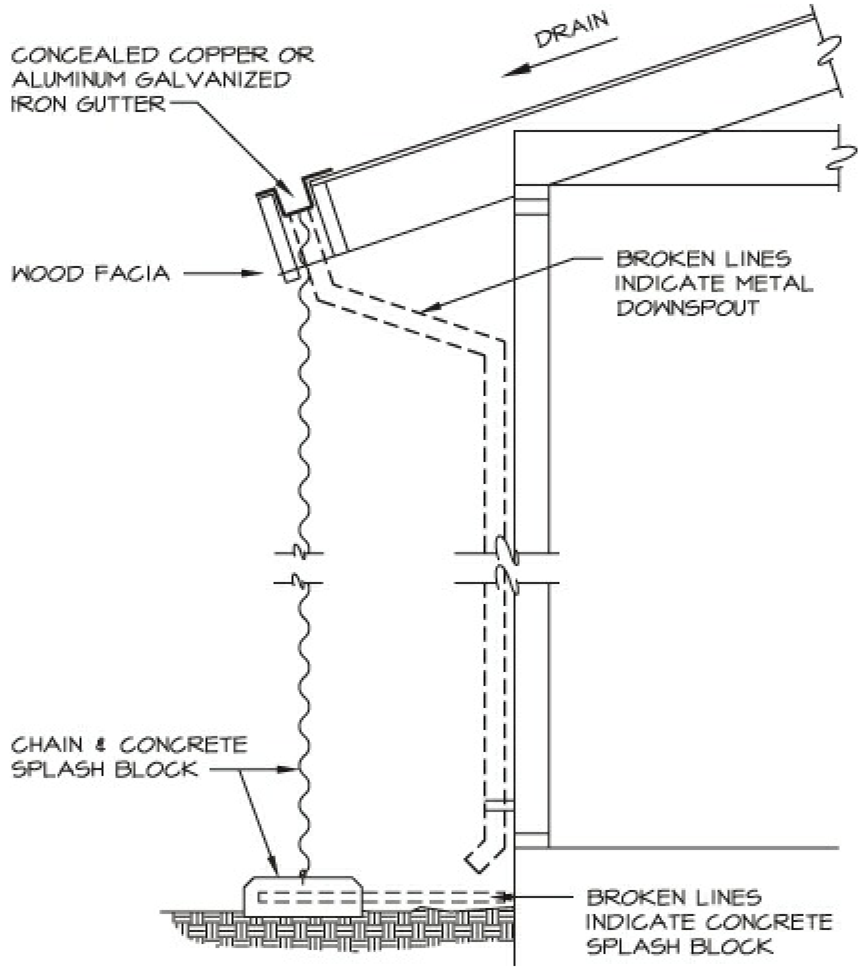


Figure 4.45 Roof draining examples.

Figure 4.46 illustrates another method of dispersing water drainage, which utilizes a gravel…filled pit encased in a concrete or vitreous container. This method may be restricted in areas where the soil conditions are not conducive to dispersing water this way. For instance, this may not be a good idea for hillside property where slides may result. The enclosed gravel areas are referred to as drywells.

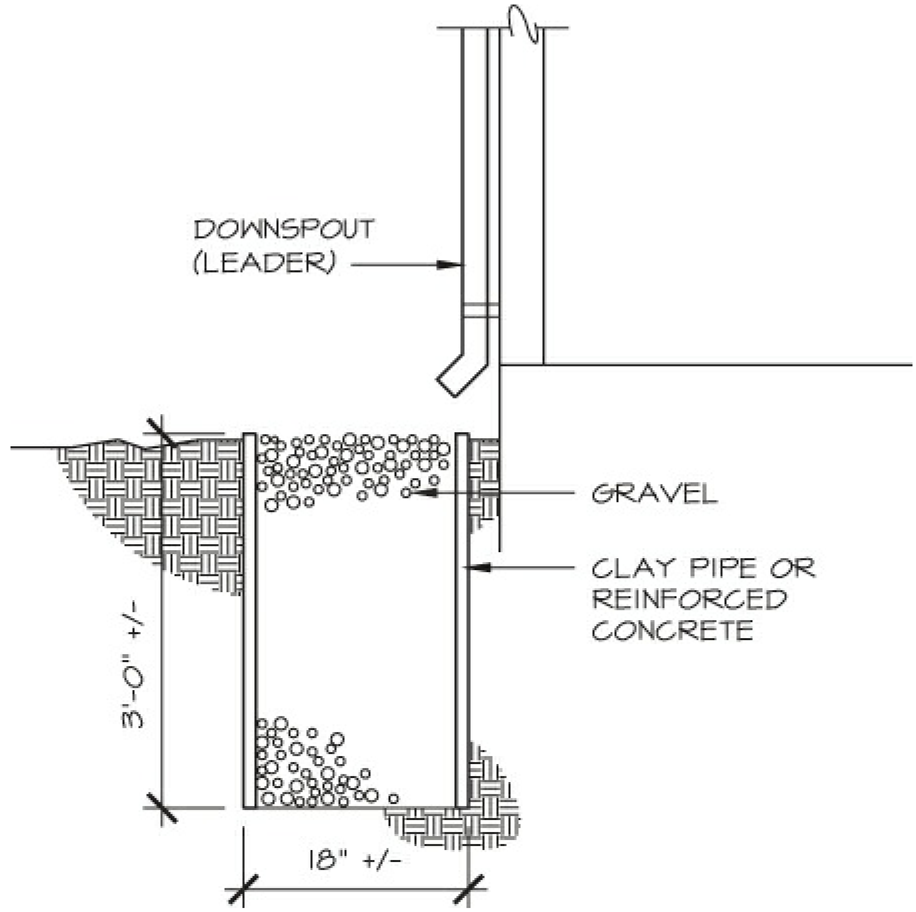


Figure 4.46 Roof downspout drainage.

In areas where soil conditions may dictate how water drainage is dispersed, other methods for roof drainage will be required. If you design drainage for wetland areas, check with your local building department. Figure 4.47, a gray…water option, illustrates a detail in which the downspouts or leaders are connected directly to a vitreous clay pipe that conducts the water to other drainage devices. The sizes of the downspouts or leaders and drainage pipes are determined by the tributary areas of the roof that conduct water to any one of the downspout locations.

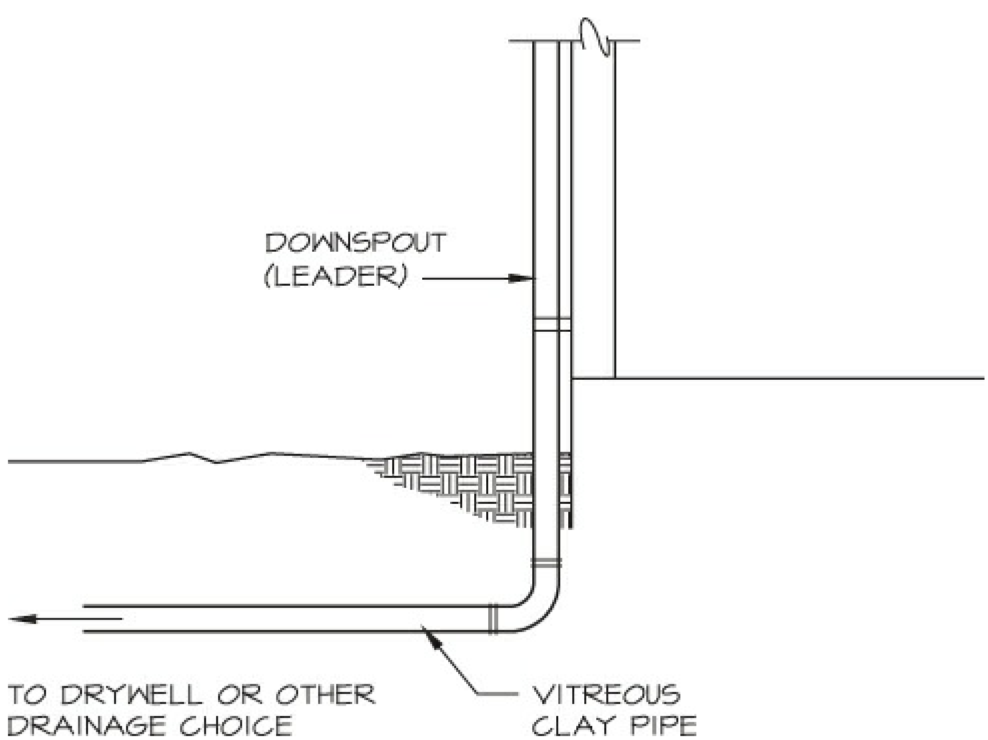


Figure 4.47 Roof downspout drainage.

When a drainage condition is directing the flow of water to a certain area of a building, such as a garage door, it is recommended that a trough drain, drainage pipes, and an aluminum or cast iron grate cover be used. This construction assembly will minimize the chance of water entering the garage area. See Figure 4.48. Note in the detail that cast iron, vitreous clay, or polyvinyl chloride (PVC) pipe is located at the ends of the trough to conduct the water away from the building.

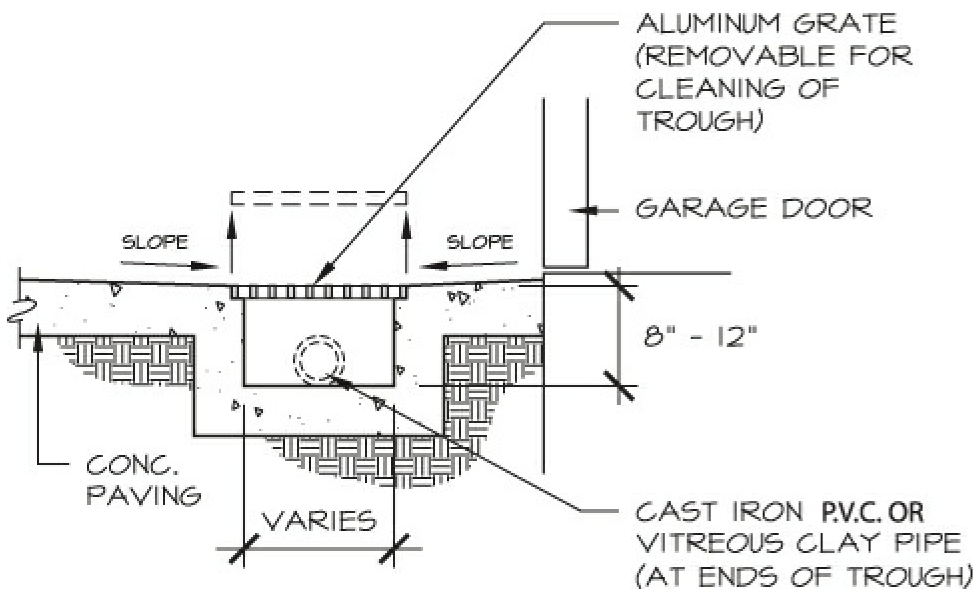


Figure 4.48 Trough drain detail.

A frequent problem at a sloping site is how to control the rainwater and reduce the erosion caused by a concentrated rainwater flow. A recommended method is installation of a concrete swale or drainage pipes on the downslope to collect the rainwater and conduct the flow into recommended drainage disbursement or erosion devices. Depending on the slope of the downhill area, numerous swales and drainage pipes may be required.

If the water flow is to be distributed on an existing site, it is recommended that a method of dissipating the flow of water be designed to deter or minimize erosion of the soil. One way to dissipate the concentration of water flow and control soil erosion is to construct a drainage device referred to as a **riprap**. This device is placed in a location where it can collect the water from swales and/or pipes. It is constructed with a concrete base and inlaid with broken concrete or protruding rocks, which are spaced apart to slow down and dissipate the water flow. See Figure 4.49.

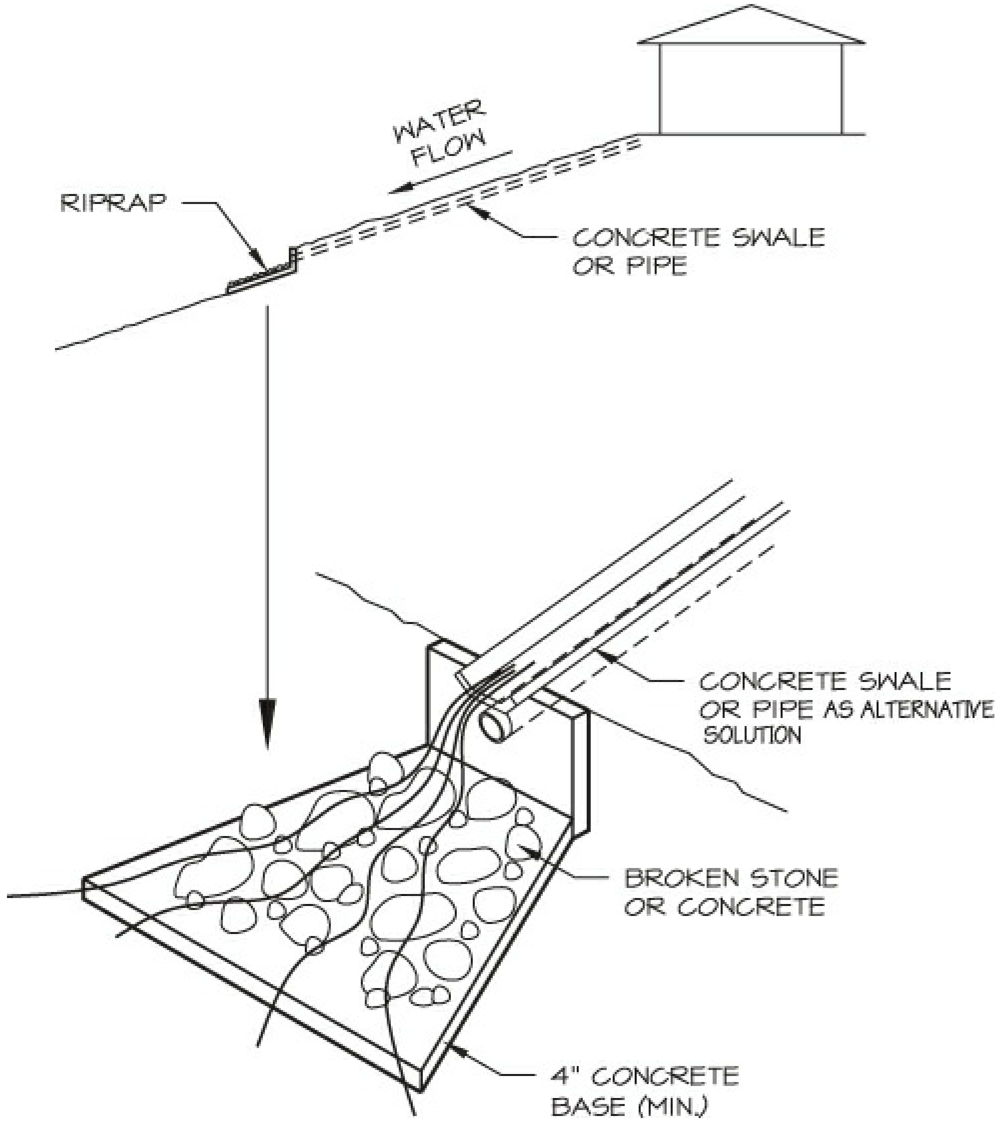


Figure 4.49 Riprap detail.

MOLD

Introduction to Mold

Mold is a topic that is very rarely described but is necessary information for students and professionals in the field of architecture. There may be described, in all geographic locations in the United States and foreign countries, the existence of tens of thousands of different molds that affect a particular geographic area.

Real estate, site design, and any kind of investment in property requires an understanding of how the various types of mold affect your geographic area. In Southern California, there are about 30,000 species of mold. Three types are considered dangerous to health: *Chaetomium, Stachybotrys* (which is a black airborne mold), and mycelial fragments. In the state of Washington, there is a 30,000…acre parcel of land that started with one single family of mycelial fragments. If, as an investor, you purchased a few acres of this particular property, hired a land developer or an architect to develop it without researching and having a person from a mold abatement company evaluate the acreage, you would be jeopardizing the health and safety of all of the clients who use your facility,

the individuals who built the new structure, and even the land developer/designer who designed this property and prepared construction documents for its erection. Imagine the lawsuits that would transpire—and the only winner would be the lawyers. Look at Figure 4.50, which shows an interior wall that has been infested with mold that now is beginning to leach out into the opposite side of the drywall. A reliable mold abatement company can remove the drywall and the mold and restore the wall to a condition similar to a brand… new framed wall.

Figure 4.50 Mold infested interior.

We suggest that you explore and research various mold abatement companies in your area and find out what the dangers are in your particular geographic area.

ENERGY SOURCES

Wind

If you seek to use wind for energy and cannot use a propeller…type wing unit, there is now an alternative. The U.S. military uses a hybrid form of what is called a **vertical axis wind turbine (VAWT)**, which converts wind energy into electrical power. This omnidirectional, low…speed generator can be used practically anywhere that has good wind exposure. Presently, the unit size is 30″ in diameter and 8′ high, weighs 60 pounds, and rotates from a speed of 0 to a 600…rpm peak. It remains visible to birds as the speed increases. See Figure 4.51.

Figure 4.51 Wind…power air turbine.

(Wepower LLC ©.)

Because of its relatively small size and the fact that it can be effective in almost any vertical position, this application lends itself to designs that are curvilinear and kinetic in nature.

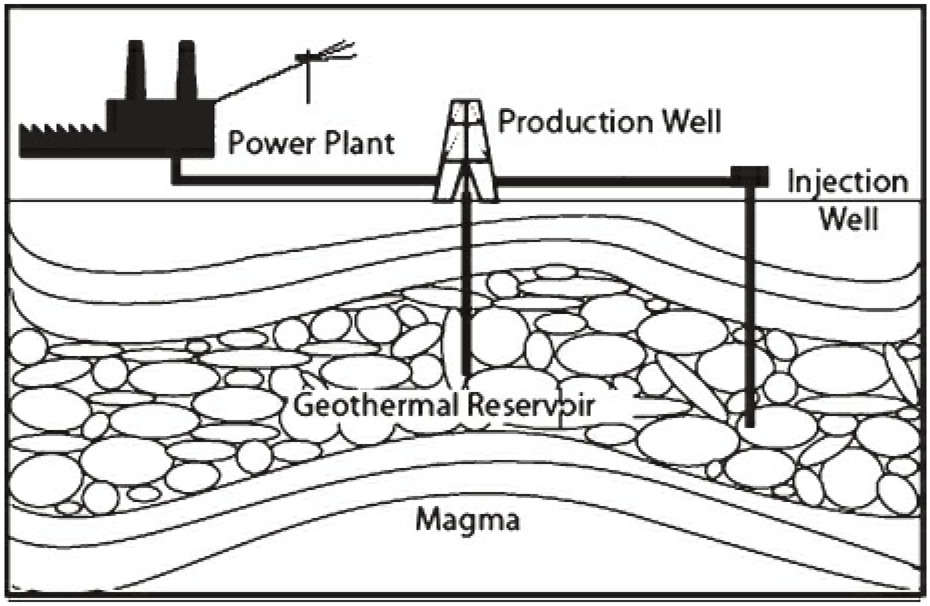
Geothermal

If you are one of the lucky inhabitants of an area that nature has provided with **geothermal** energy (a name that comes from the term **geothermic**, having to do with the heat of the Earth's interior), you should look into the feasibility of tapping into this natural resource. Geothermal energy is accessible in many areas around the world; Figure 4.52 shows the locations of the best of these areas. If you are in one of these geothermal zones, you must first investigate the cost, how you can amortize the cost of installation, and the impact the equipment will have on the aesthetics of the structure. Remember that cost rebates may be available through the federal or state government or from a public utility.

Figure 4.52 Hottest known geothermal areas.

(Courtesy of U.S. Department of Energy, Geothermal Education Office, Earth Policy Institute.)

In California, a production well is drilled in excess of a mile to reach the hydrothermal reservoirs, where 80% of the state's geothermal energy lies. Steam from these reservoirs, which can reach temperatures of 360°F, is used to turn turbines; the electricity produced thereby is distributed via power lines. The cooled water returns to the reservoir by way of an injection well. Returned water is reheated and may be used over again. The whole process is shown diagrammatically in Figure 4.53.



[Figure 4.53](#) Tapping geothermal areas.

Areas that have hot springs, such as Idaho, often simply use those springs to heat buildings in the winter. It might also be practical to go down into the earth some 80 to 100 feet and use the natural temperature of the earth to cool or warm a building.

Solar

One of the best uses of solar energy applications, from both functional and aesthetic standpoints, is the giant metal flower located in the United Nations Plaza in Buenos Aires, Argentina. Designed by Eduardo Catalano, the "Floralis Generica" sits in a reflecting pool in a park full of plants and flowers. (The designer chose the name *Generica* to indicate that the installation is a symbol of all flowers.) Its petals, each of which measures 13 meters long by 7 meters wide and incorporates solar panels, close in the evening and remain closed from sunset to sunrise. During the day, it moves in 20…minute intervals to mimic a flower—a perfect marriage between technology and nature. See it on the chapter opener.

Three of the most natural, free, and significant solar energy sources are heat, light, and ultraviolet rays. We can use two out of three of these sources. The third (ultraviolet rays) causes cancer in humans, but it induces the production of vitamin D.

Knowledge of the Sun. In its simplest form, the sun can be a negative in architecture. If, for example, we let direct sun into a structure in order to get light and heat, we also create a health hazard: prolonged exposure to the sun's ultraviolet rays is known to cause both basal cell carcinomas (skin cancer) and melanoma (a more serious form of cancer).

Position of the Sun. If you can control the temperature extremes and glare that the sun creates in the structure, you will have captured and made the best use of the sun's solar energy. To attain this control, you must determine the longest day and the shortest day at the building site. June 21 and December 21, known as the summer and winter solstices, respectively, are what we as architectural designers must seek out prior to executing a

design. The summer and winter solstices can best be determined by finding the sun's angles to the Earth and locating its latitude. **Latitude** refers to (artificial) horizontal markings we have placed on the Earth; **longitude** refers to the vertical markings we use as a datum. (It is easy to remember which is which when you pronounce these words: Note the shape of your mouth as you say *latitude* or *longitude*. Your lips will get wider when *latitude* is spoken, and the "long" of *longitude* will be pronounced with more vertically formed lips.)

Latitude. Clearly, many of you already know how to find the latitude of a given city. For beginners, we suggest that you access the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) web site on your computer. It will direct you to NOAA's new solar calculation. It even gives you specific directions on how to use the solar calculation (remember that you want latitude). For example, if you type in "Berlin, Germany," 52°19′48″ will appear. If you are a student, find out if the architecture department has a device used to measure the vertical and horizontal angles of the sun at a given time based on the latitude of the location. Charts of such information are available; see Figure 4.54 for a listing of states and their latitude range.

Alabama	30–35°
Arizona	31–37°
Arkansas	33–36°30′
California	32° 30–42°
Colorado	37–41°
Connecticut	41–42°
Delaware	38 30′...42°
District of Columbia	39°
Florida	25–31°
Georgia	31–35°
Idaho	42–49°
Illinois	37°–42°30′
Indiana	38–42°
Iowa	41–43°
Kansas	37–39°
Kentucky	37–39°
Louisiana	29–33°
Maine	43–47°
Maryland	38–40°
Massachusetts	42–43°

Michigan	42–47°
Minnesota	43° 30′–49°
Mississippi	30–35°
Missouri	36–41°
Montana	45–49°
Nebraska	40–43°
Nevada	35–42°
New Hampshire	43–45°
New Jersey	39–41°
New Mexico	31–37°
New York	41–45°
North Carolina	34–37°
North Dakota	46–49°
Ohio	39–42°
Oklahoma	34–37°
Oregon	42–46°
Pennsylvania	40–42°
Rhode Island	41–42°
South Carolina	32–35°
South Dakota	43–46°
Tennessee	35–37°
Texas	26–36°
Utah	37–42°
Vermont	43–45°
Virginia	36° 30′–39°
Washington	46–49°
West Virginia	37–41°
Wisconsin	42° 30′–47°
Wyoming	41–45°

Figure 4.54 Range of latitude by state.

Suppose that you were interested in Las Vegas (36°–10′) and Berlin (52°–19′±). Charts may be available for 52°+ and 36°+, such as the one for Berlin found in Figure 4.54, or you may find this information via computer. AutoCAD is preloaded with latitude ranges for almost every city and country in the world. If you input the date, day, latitude, and

time of the day, the program will give you the vertical angle and the horizontal movement of the sun. If you want to see the shadow patterns from a building, you must insert the day, date, latitude, and the specific hour before AutoCAD can give you the results. However, the process is cumbersome at best. If you want to follow the shadow pattern for a specific date, it is much quicker and easier to use Revit, which can do this for you. See Chapter 1 for such a display. If you do not have Revit, you could still plot the data in Figures 4.55 and 4.56, though it is a time…consuming process.

Winter Dec 21		
	Vertical Angle	Horizontal Angle
Sunrise	0°	S 42°
10:00 AM	9°	S 30°
12:00 (Noon)	12°	S
2:00 PM	10°	S 31° W
Sunset	0°	S 42° W
Summer June 21		
	Vertical Angle	Horizontal Angle
Sunrise	0°	E 49° S
8:00 AM	30°	E 21 1/2° S
10:00 AM	54…1/2°	E 35° S
12:00 (Noon)	64…1/2°	S
2:00 PM	56° S 57°	W
4:00 PM	37° W 1°	N
Sunset	0° E 48°	N

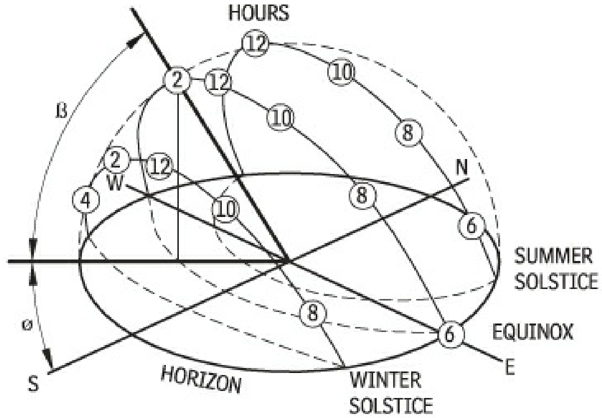
Figure 4.55 Berlin (52°–19±′).

Winter Dec 21		
	Vertical Angle	Horizontal Angle
Sunrise	0°	E 34° S
10:00 AM	21°	E 60° S
12:00 (Noon)	27°	S
2:00 PM	21…1/2°	S 36° W
4:00 PM	6°	S 60° W
Sunset	0°	S 67…1/2° W
Summer June 21		
	Vertical Angle	Horizontal Angle

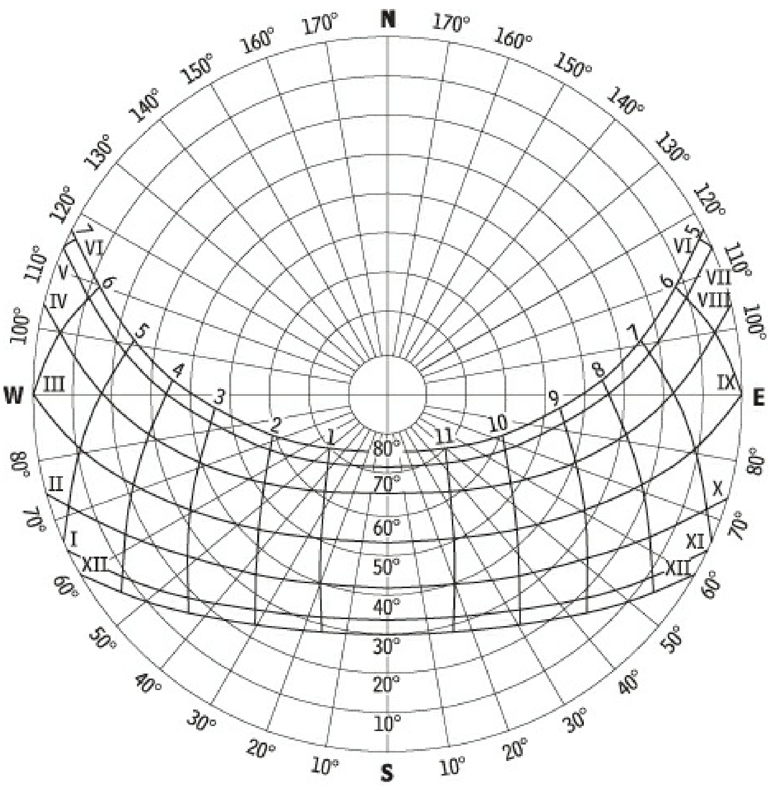
Sunrise		E 3° S
8:00 AM	36°	W 11° N
10:00 AM	56°	E 21° S
12:00 (Noon)	80°	S
2:00 PM	62°	W 6° E
4:00 PM	37°	W 11° E
Sunset	0°	W 37…1/2° N

Figure 4.56 Las Vegas (36°–10±').

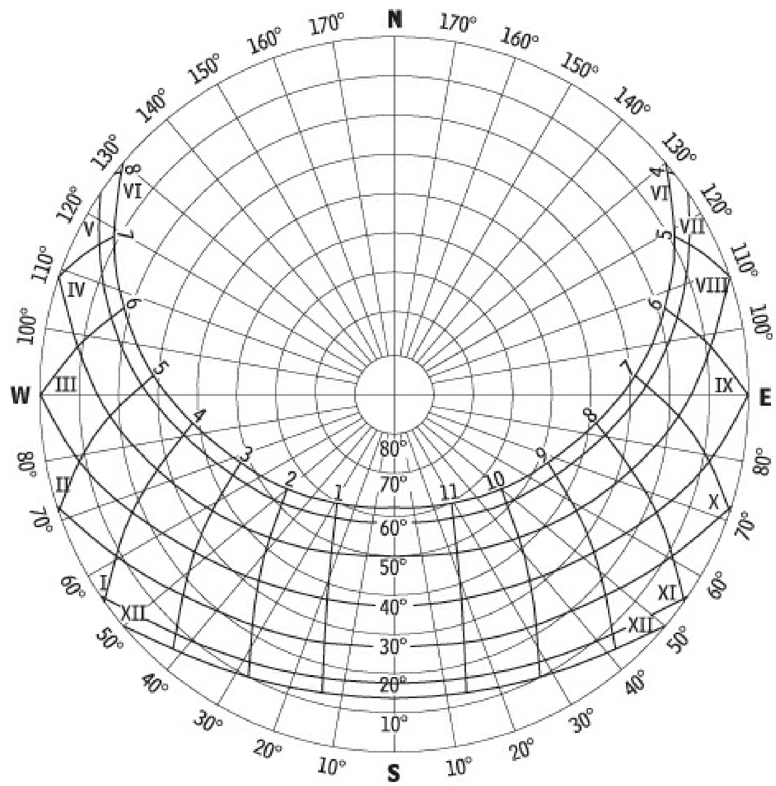
In the recent past, one would take the information such as that found in Figures 4.55 and 4.56 and plot the data points to produce a diagram like that in Figure 4.57. View A is a top view, like a CT scan, for 52° latitude and 36° latitude, approximately the latitude of Berlin and Las Vegas. Another method would be to find a series of charts for this desired latitude, similar to those in Figure 4.57 B and C, and laboriously plot the shades and shadows. This would assist the architect in designing the window/glass door locations, patios, landscape, and overhang of the roof, to mention just a few applications.



DWG # APP.1_12



DWG # APP.1_16



DWG # APP.1_20

[Figure 4.57](#) Sun position by latitude.

(Architectural Graphic Standards CD‥ROM, © 2000 by John Wiley & Sons.)

What to Expect. If you know how to effectively determine the interaction of the sun and a building, but do so only as an afterthought, you have done a disservice to the client. It is better to consider and verify the factors of heat gain and light penetration before the structure is designed. Validation after the fact is fine, but it is too late to change the design at that point. You must know the effects of the sun on your proposed structure at any time and date, and use that knowledge to inform and enhance your design.

Plotting in 3‗D. Check your site and establish the bearing (N, S, E, W). Then plot the movement of the sun on June 21 and December 21 (see Figure 4.58). This will give you an idea of how the sun moves across the sky in the winter and the summer. Next, show the step, drawing your sets onto the grid. Now you are ready to design your structure—or maybe not! You will also want to explore the prevailing wind in conjunction with the sun, correlate the annual rainfall, noise, and so on. BIM suggests that you check all the elements in select materials by rotating a 3…D model of the structure on the site, to determine the effects of rain, wind, and other elements on the structure. As educators, we suggest that you study and learn about one design element at a time, even though you will eventually have to consider all of them when you execute a design.

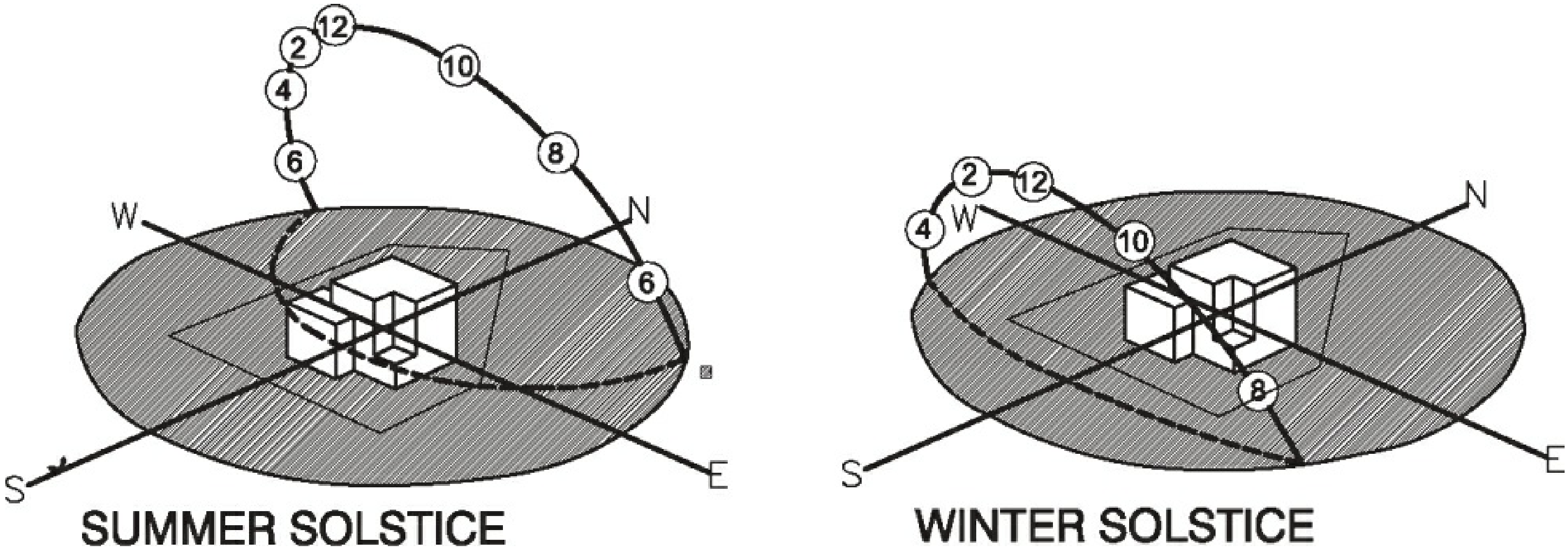


Figure 4.58 Checking massing forms with summer and winter solstices.

GREEN ARCHITECTURE

If we are to implement "green" architecture, we must design and build structures with reduced energy use and costs. Residential and commercial buildings account for 40% of our total energy use, 70% of our electricity use, and 12% of our water use. Also, 30% of our greenhouse gas emissions come from structures.

Sustainable design uses environmentally sensitive design to reduce this negative impact on the environment. In the United States, a voluntary system called Leadership in Energy and Environmental Design (LEED) was established as a national standard for design. As many as 69 points (maximum) can be earned for a site design, for good indoor environment quality, and for efficient use of energy, materials, and water. Why are LEED's points critical? Because adherence to LEED criteria may make a project eligible for governmental funding: The higher the points, the higher the possible funding.

A good example of LEED is the Aria Resort and Casino complex, which includes a hotel and spa, the Mandarin Oriental Las Vegas, Veers Towers, and the Crystal retail and entertainment district. The main entry to the City Center (with LEED gold certified buildings) is by way of the Daniel Liebeskinds' Crystal retail center featured on the cover

of this book. The Aria, designed by high…profile architects including Daniel Liebeskind, Pelli Clarke Pelli, and Kohn Pedersen Fox, is one of the first Las Vegas hotels to achieve LEED gold certification, and is the world's largest hotel with LEED gold status.

FUTURE OF ENERGY SOURCES

Even though proven alternative energy sources, such as biofuels, wind, solar, water, and geothermal, currently exist, their technical adoption has not yet delivered enough of a financial advantage for the U.S. population to fully embrace them. It can take 20 to 30 years to amortize the installation cost, and because people often move from residence to residence more frequently than that, they tend not to invest in energy…saving devices and fixtures in their homes. The same is true in the business arena, where many businesses are only tenants and unwilling to improve the landlord's property out of their own pockets. The state and federal governments have thus been forced to subsidize alternative…energy investments with grants, tax rebates, and other incentives so as to break this mind…set.

Solid oxide fuel cells (SOFCs) have garnered interest since an SOFC system was used in space travel starting in the 1960s, but they have not yet been incorporated into our daily lives because of the cost and low efficiency. We need a clean, efficient, reliable, and affordable SOFC, which until recently had not been available. K. R. Sridhar, a rocket scientist, took one of the inventions he had created for space travel (specifically, a Mars landing), reversed the process, and created a wireless energy…producing cell called the Bloom Energy Cell. Bloom Energy claims that its clean, reliable, and affordable energy source will pay for itself in three years and leave a lower carbon footprint while doing so. The Bloom cell is appropriately termed “plug and play”: It is made to fit into any infrastructure and requires no end…user maintenance (Bloom Energy handles all management and maintenance of its systems).

After the company was founded in 2001, it spent a year finding funding and the next three years in research and development. In 2006–2007, it performed field trials, product testing, and validation. The first commercial shipment occurred in 2008.

Customers include Bank of America, the Coca…Cola Company, eBay, Cox Enterprises, Staples, and Google. Since its inception, Bloom devices have produced more than 11 million kilowatt hours for its customers; more importantly, users have reduced their carbon footprints by more than 14 million pounds. It has been said that this represents the equivalent of powering 1000 average U.S. homes (2000 European homes) and planting a million trees.

Each Bloom Energy Server is composed of hundreds of fuel cells. These fuel cells, which are about the size of a CD container, are assembled from simple components such as sand and metal. (Look at the bottom of the diagram in Figure 4.59.) One fuel cell can produce enough electricity to power a 25…watt bulb. A stack of these would power a European (7…kw) home, while a twin stack would power a U.S. (2…kw) home. One large Bloom Energy

Server (100 kw) could power 100 U.S. homes or a supermarket.

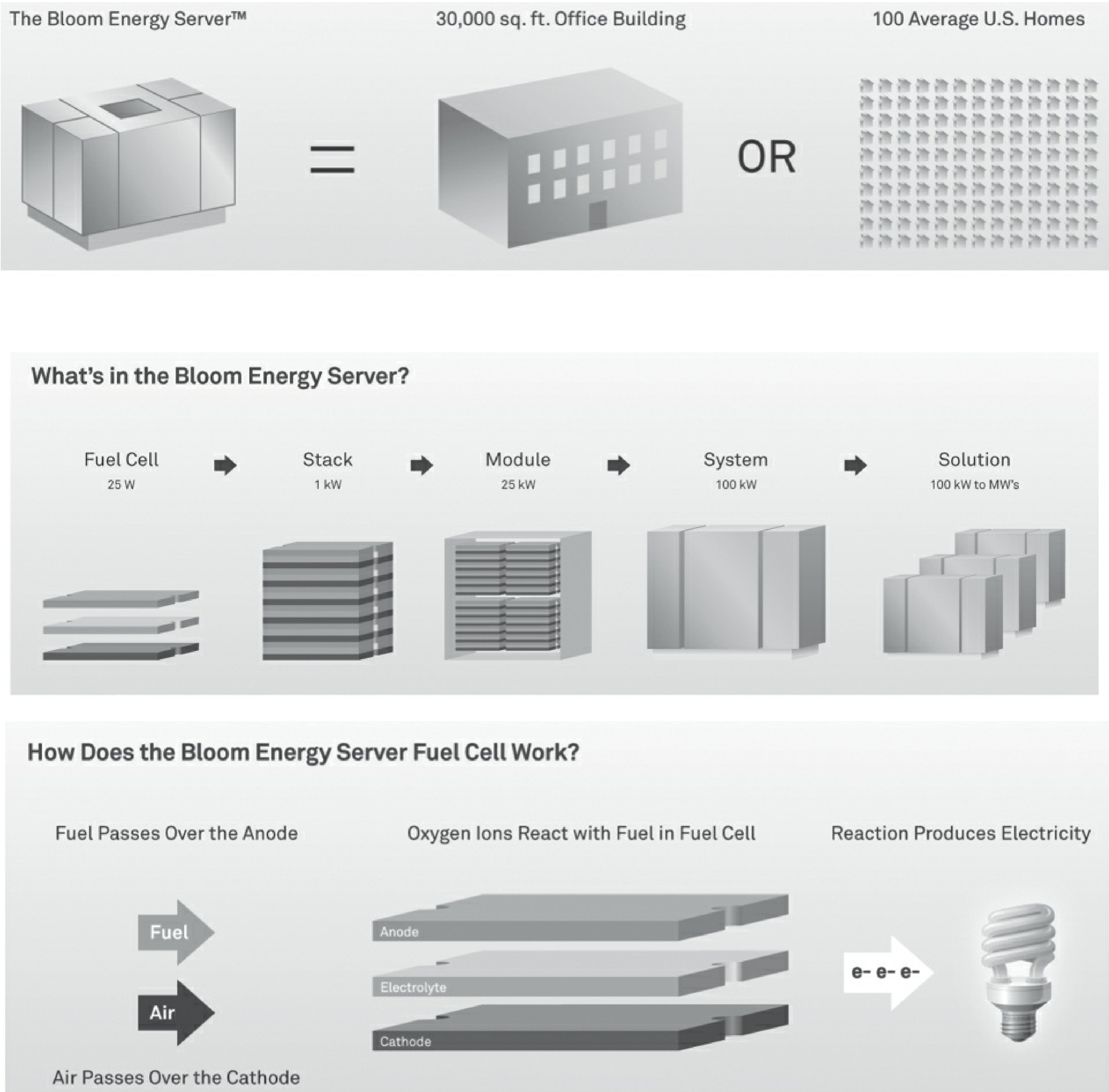


Figure 4.59 Bloom Energy Server.

(Courtesy of Bloom Energy.)

This capability, in conjunction with state subsidies and federal rebates to offset acquisition and installation costs, is expected to make Bloom Energy systems available for the entire country within 10 years. Because it is wireless, it can also be used where there is no other electricity capacity, especially in third…world countries.

Summary

It is not sustainable to build by exporting significant grade from the site to a landfill or another location; in fact, we feel that trucking tons of soil offsite is just about the least sustainable thing an architect can do. Use the excess earth to improve the flow of water more efficiently, landscape with it to separate private space from public space, or create a berm (ledge or shoulder along the edge of the site) to control street noise.

In this chapter, we have only briefly discussed the leading available energy sources. Many factors must be considered for a green design, including cost, environmental impact, and the project's individual contribution to preserving the available energy sources. Maximize the positive global impact of your structure!

For the construction documents, especially the working drawings that are our primary responsibility, you must carefully consider the following:

1. Will the use of a particular design element affect the structure overall? For example, the decision to change from asphalt shingles to a tile roof will also increase the weight of the roof, as well as the cost of the roofing product and the larger roof members required. You must balance the change in the roof framing and size against the greater energy savings yielded by a tile roof.
2. Will this project include alternative energy sources such as the wind turbine discussed earlier? If so, will the manufacturer install the wind turbines, or will this task fall to the contractor? If installation becomes the contractor's job, what type of drawings will the contractor need—working drawings or shop drawings? **Shop drawings** are done by the manufacturer rather than the architectural firm. Any drawings provided by the manufacturer must be compatible with the structure and the existing working drawings, and preserve the uniqueness and structural integrity of the application; do not settle for just a generic solution to a “typical” installation. Many products are required to be installed by the vendor of the product, to maintain and safeguard the warranty.
3. The product must meet local codes and be built in a manner suitable for its intended use. However, the product used must also be compatible with the larger project or structure being executed; it must not look alien or incongruous.
4. Do not use a product just because “everyone” is using it. Do your own investigation to validate its use in your particular project. Determine whether the product is truly green; do not simply accept the manufacturer's claims or statements in this regard.

Key Terms

envelope

frost depth

frost line

geothermal

geothermic

green architecture

latitude

longitude

moment frame

pressure…treated (PT) wood

rigid frame

riprap

shop drawings

slip joints

sump pit

sustainable (architecture)

vertical axis wind turbine (VAWT)

water table

Chapter 5
CONSTRUCTION MATERIALS AND METHODS

BUILDING MATERIALS

Materials and Systems

Building construction incorporates various building systems, materials, and construction

principles. These systems, materials, and principles are generally selected for the following reasons:

1. The type and use of the proposed structure
2. Governing building code requirements
3. Architectural design and planning solutions
4. Structural concepts
5. Economic considerations
6. Environmental influences
7. Energy requirements

The use of one or more materials for a proposed building may be predicated on reasons such as building code requirements or the building occupancy; architectural design; energy and climatic conditions; and the influence of natural forces, including high winds, seismic events, infestation, and moisture. For most structures, the main materials used are wood, concrete, structural steel, masonry, light steel framing, and composite materials. For many structures, a combination of materials may be utilized. The primary components of construction systems include the foundation and floor systems, and the wall and roof systems.

The primary materials utilized in construction systems are the following:

1. Wood—sawn lumber and manufactured lumber, often called **engineered lumber**
2. Concrete
3. Structural steel and light steel framing
4. Masonry, brick, or block
5. Composite systems with a combination of materials
6. Recycled/reclaimed

WOOD AS A MATERIAL

Wood Materials

The layout of a floor plan using a wood stud framing system is very flexible in comparison to that of a floor plan using another material. This is because openings in the exterior and interior walls are not restricted by a modular unit or other material constraints. Wood also performs well in environmental conditions such as seismic events or hurricanes.

When a conventional wood stud framing system has been selected for the floor, walls, and roof systems, the floor plan drawings must be graphically correct. For example, a wood stud wall system is presented with the use of two parallel lines, which may be

drawn to scale, incorporating the wood stud size in combination with the exterior and interior finishes. An example of a floor plan for a small dwelling, using two parallel lines to represent a conventional 2 × 4 wood stud wall in plan view, is illustrated in Figure 5.1. The exterior walls are dimensioned from the face of the wood stud as abbreviated with the letters "F.O.S.," indicating "face of stud." This method of dimensioning will correspond to the face of the concrete foundation footing, thus providing a good dimensional check for both the floor plan and the foundation plan. For layout purposes, the width of the two parallel lines will be the stud width of 3½″ plus the thickness of the exterior and interior wall finishes. The interior walls are dimensioned to the centerline of the walls, as indicated in Figure 5.1. Note that the 4 × 4 post is dimensioned to the centerline in both directions.

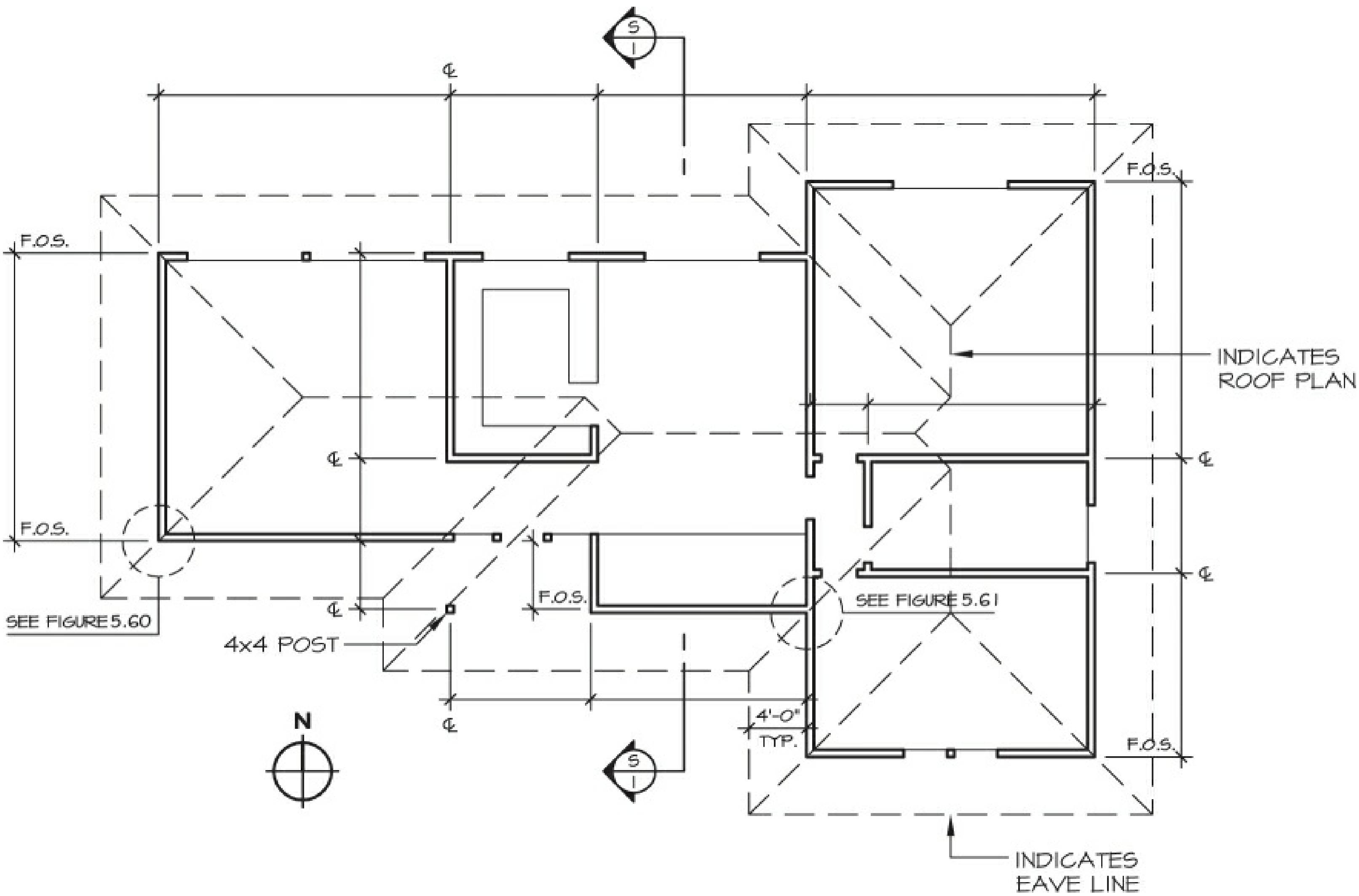


Figure 5.1 Floor plan with 2 × 4 stud framing.

Figure 5.2 represents a view of the corner framing condition for this small dwelling. This is shown to illustrate the actual dimension line as it relates to the stud face dimension. The corner layout is intended to maximize strength and accommodate the connection of the finish materials to the studs. In this example, gypsum board can be screwed to two of the interior corner studs, while the cement plaster can be nailed to the exterior corner stud.

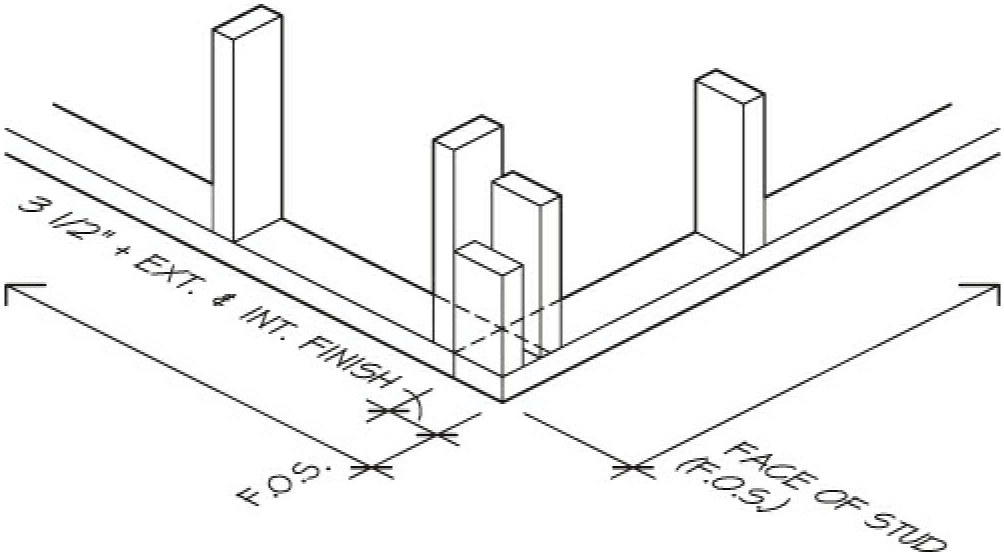


Figure 5.2 Corner framing layout.

In laying out the interior walls of the floor plan, the two parallel lines are drawn to scale, incorporating the width of the wood stud plus the thickness of the interior wall finishes. See Figure 5.3.

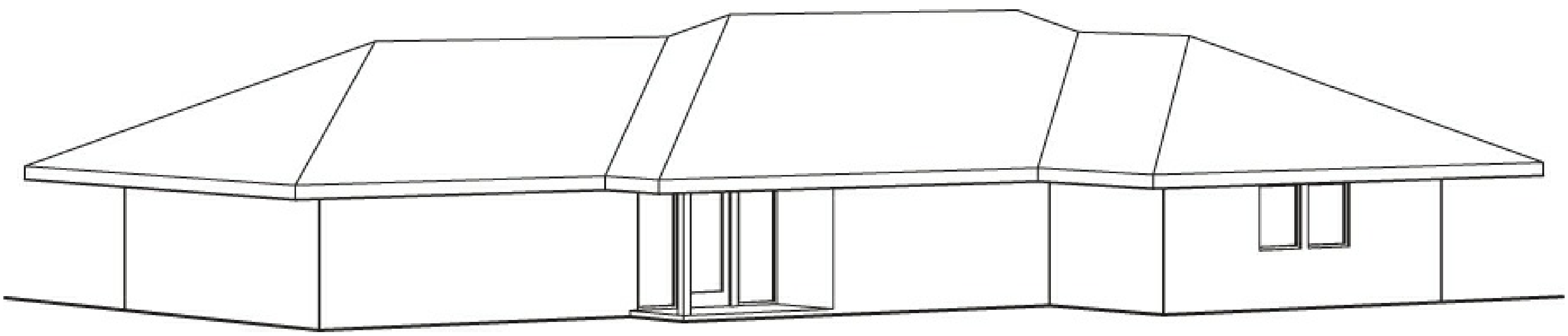


Figure 5.3 Perpendicular wall intersection.

Building Section

It is recommended that you study a preliminary building section before developing the exterior elevations. The architect determined a roof pitch, an eave overhang, and a soffit so as to terminate the finish soffit material directly above the exterior window and door trims. This design requirement also established a 9′ plate height dimension from the top of the concrete floor to the top plate. Generally, the plate heights for light residential wood structures are from 8′…0¾″ to 10′…0″. A wood stud framing system provides flexibility in the design and construction process. Figure 5.4 illustrates a building section that is cut through the floor plan at the building section symbol location on the floor plan in Figure 5.1. As indicated by the building section symbol, the section cut is looking in a westerly direction.

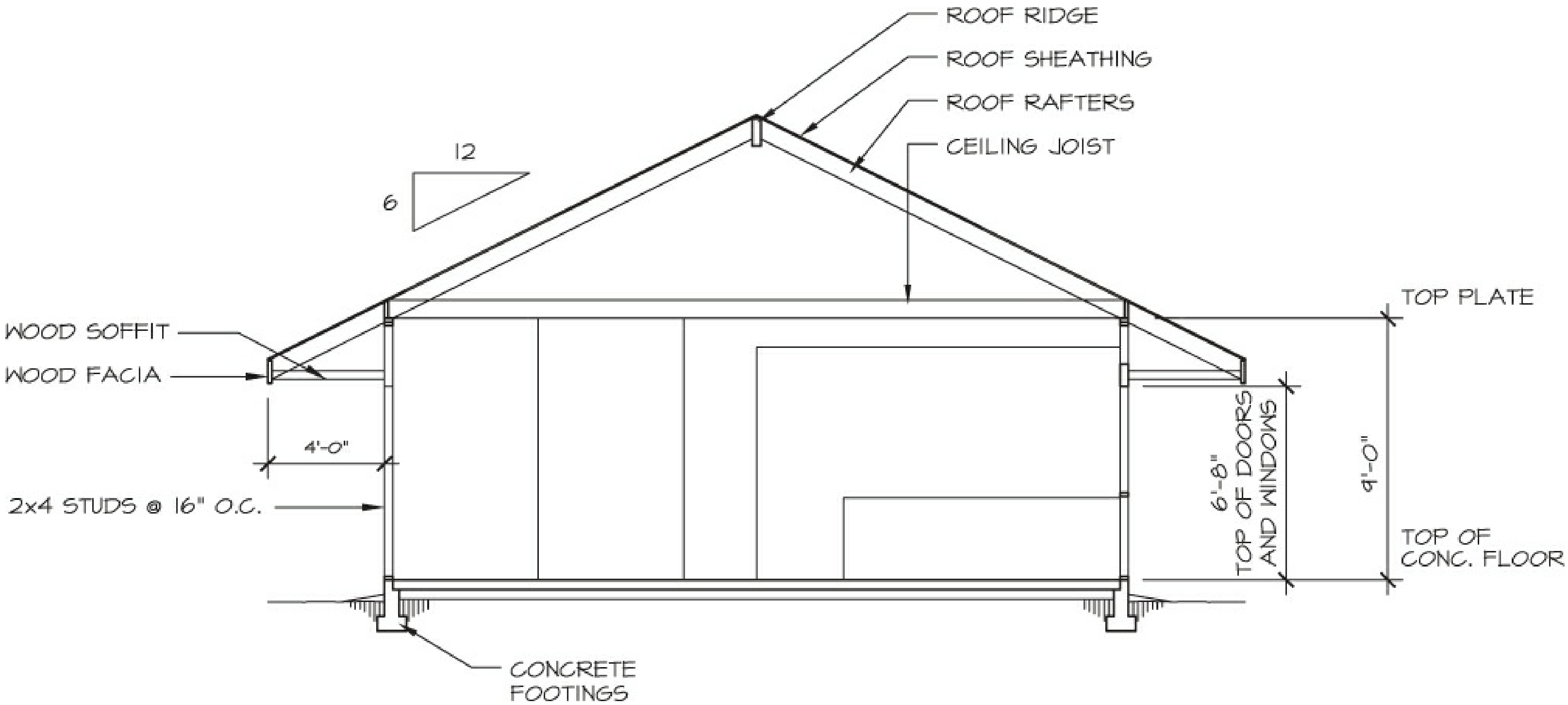


Figure 5.4 Building section.

Note that the horizontal soffit at the roof eave terminates just above the normal window and door height of 6′…8″. The size and grade of the wood supporting members in the roof system will be determined later in the working drawings by the architect or the structural engineer.

Wood Post and Beam

Another project to be built with wood may use a different format with a conventional wood stud construction system. For example, a wood modular system may be selected for the structure. This system will incorporate the use of posts and beams spaced at a preferred dimensional distance. The modular distance will depend on the type and size of the floor and roof members that will span between the modular beam systems. These members may use solid tongue…and…groove planking, sawn lumber joists, or engineered lumber joists. Modular post…and…beam systems may be used in light construction projects, such as a residence, or in the heavy timber construction of a public building. See Figure 5.5.

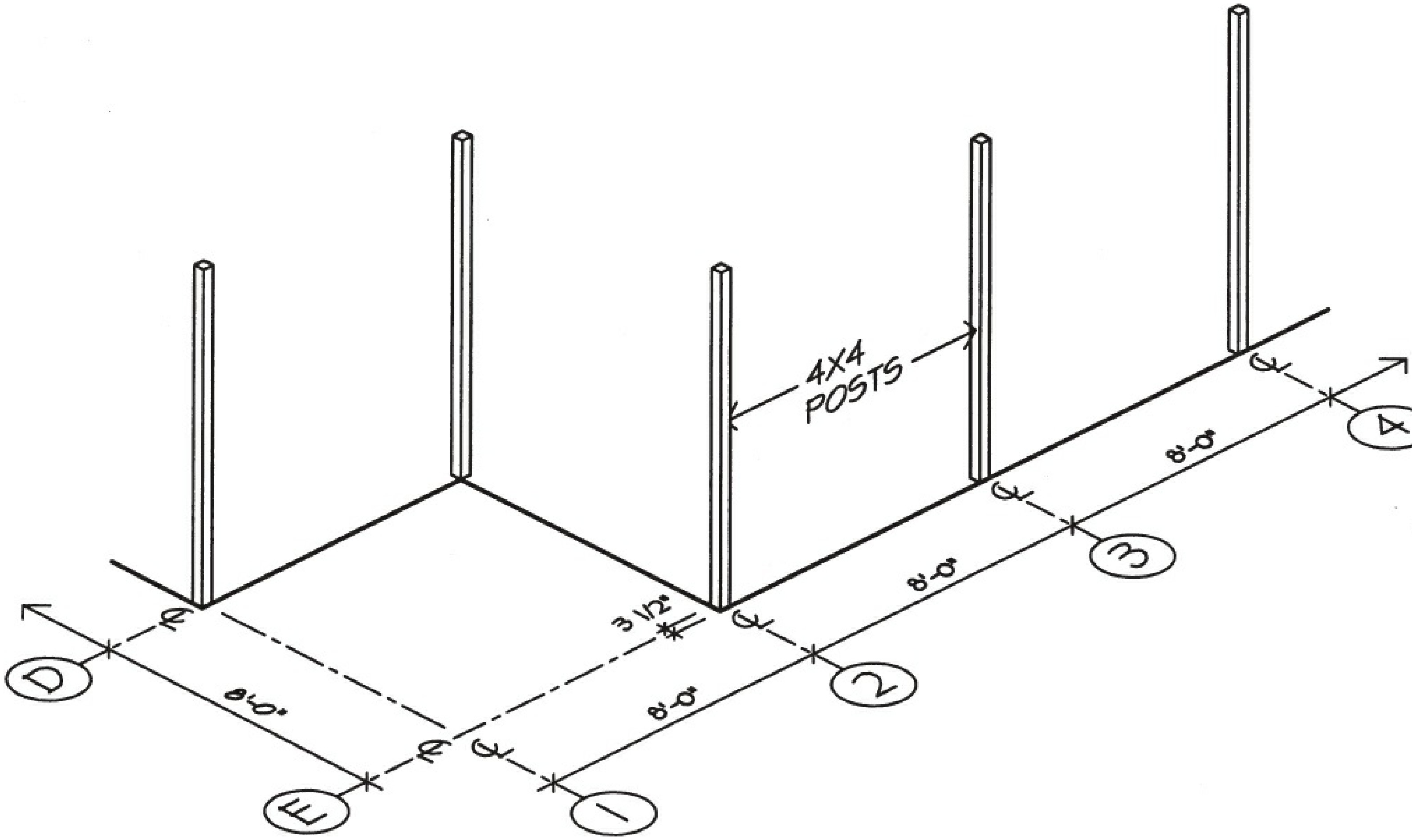


Figure 5.5 Partial modular post layout.

Floor Plan. The initial approach for development of a floor plan to be used in the working drawings for a project utilizing a wood post…and…beam system is to create a matrix system. This may also be referred to as a **dimensional reference system** (covered in Chapter 2) for the supporting post in each direction. The matrix for the wood post…and…beam system now provides the basic structural skeleton for the building's structure.

In most cases, this system is used to organize the wood structural members and the simplicity of the structural design. The dimensioning of this wood system is different from that of the conventional wood stud system. See Figure 5.6.

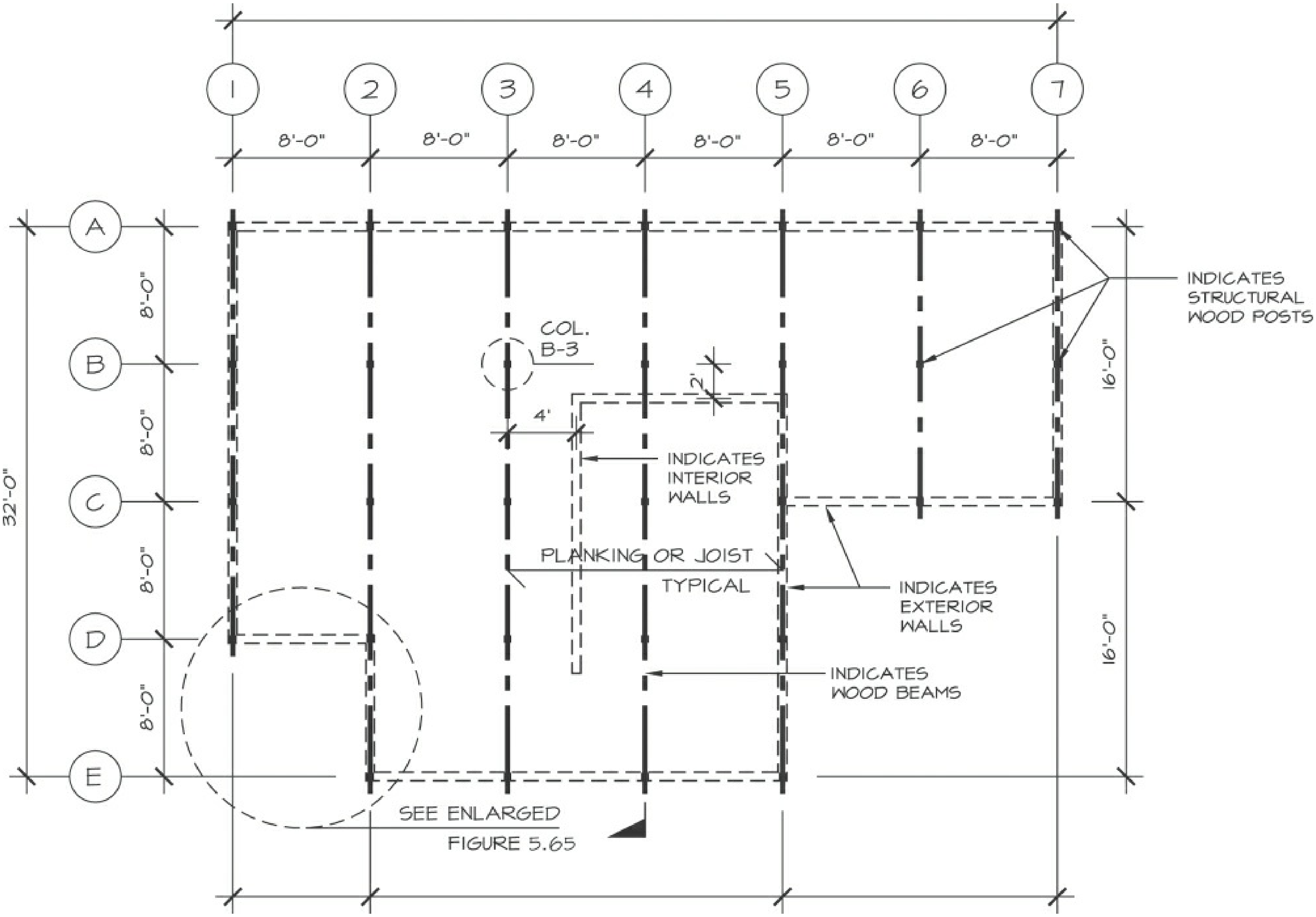


Figure 5.6 Modular wood post layout.

The post…and…beam construction method that utilizes a matrix system allows the location of any of the supporting columns and its corresponding concrete pier foundation supports. An example of locating a specific column is illustrated in Figure 5.6, where column B…3 has been defined for referencing. Any one of these specific columns can be utilized for the purpose of referencing dimension lines to the interior wall locations.

Exterior Elevations. Development of the exterior elevations for a modular wood post…and…beam system would depict the wood columns according to the matrix layout, while also establishing the desired wall and bottom…of…beam heights. In addition, the dimensioning of roof overhangs may be referenced from a specific matrix designation. See Figure 5.7. A partial drawing of Figure 5.7 is shown in Figure 5.8.

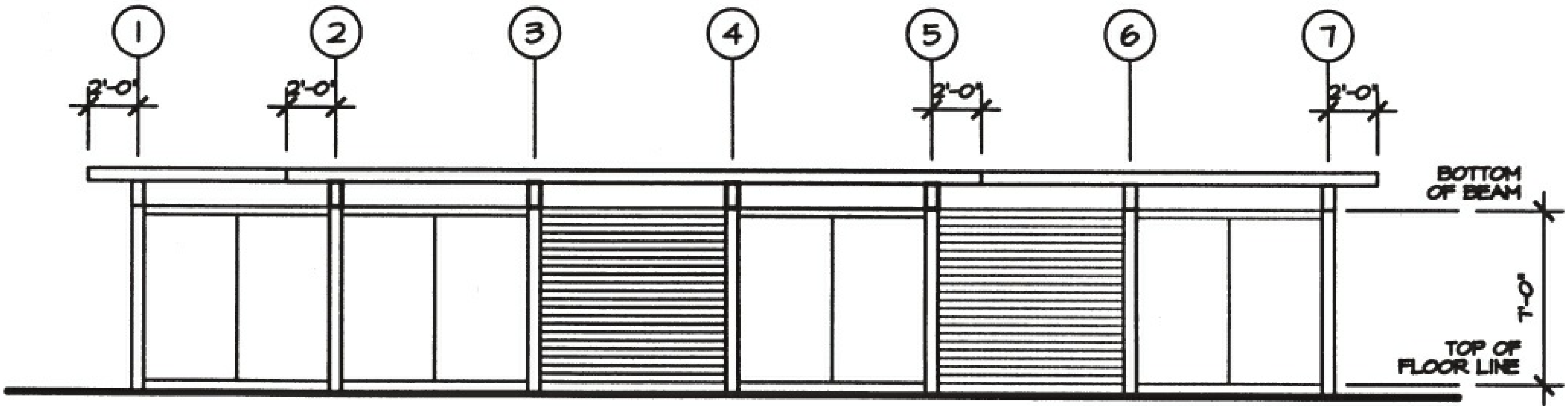


Figure 5.7 Exterior elevation of a post…and…beam system.

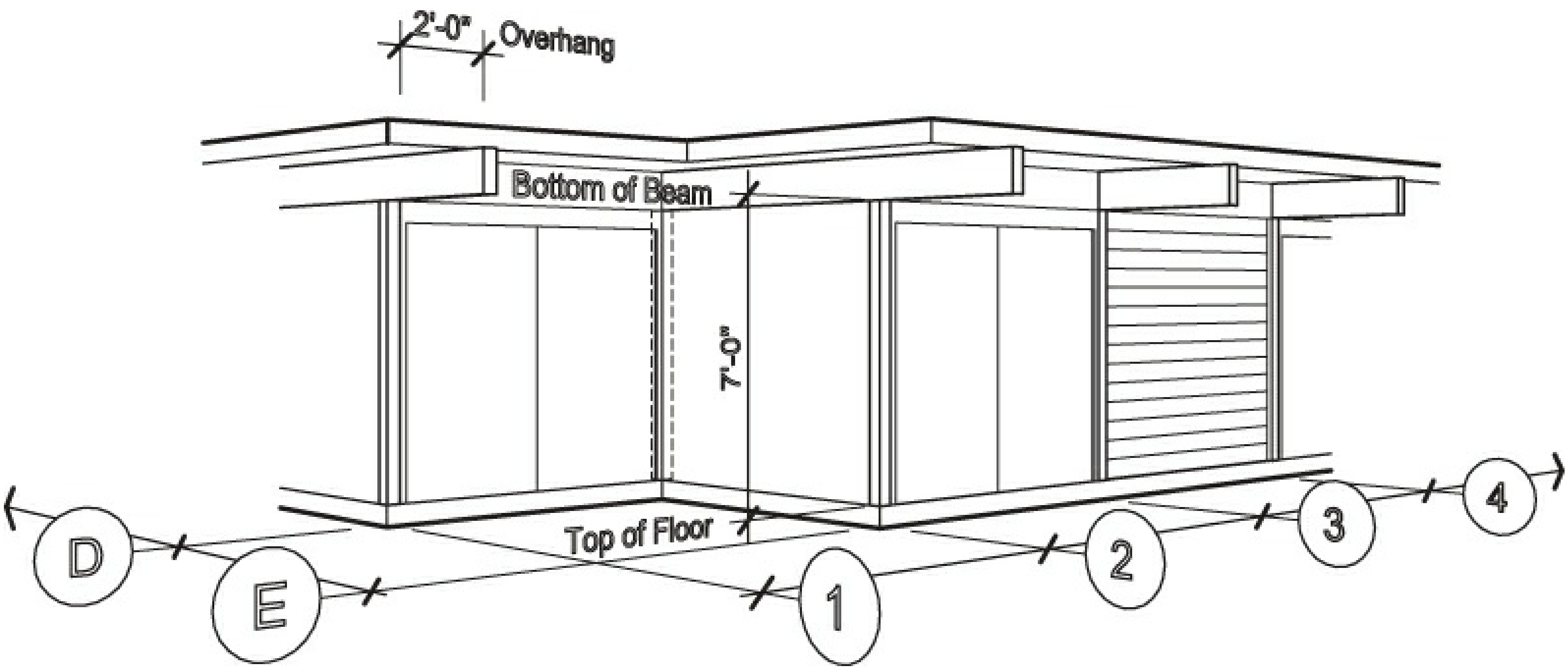
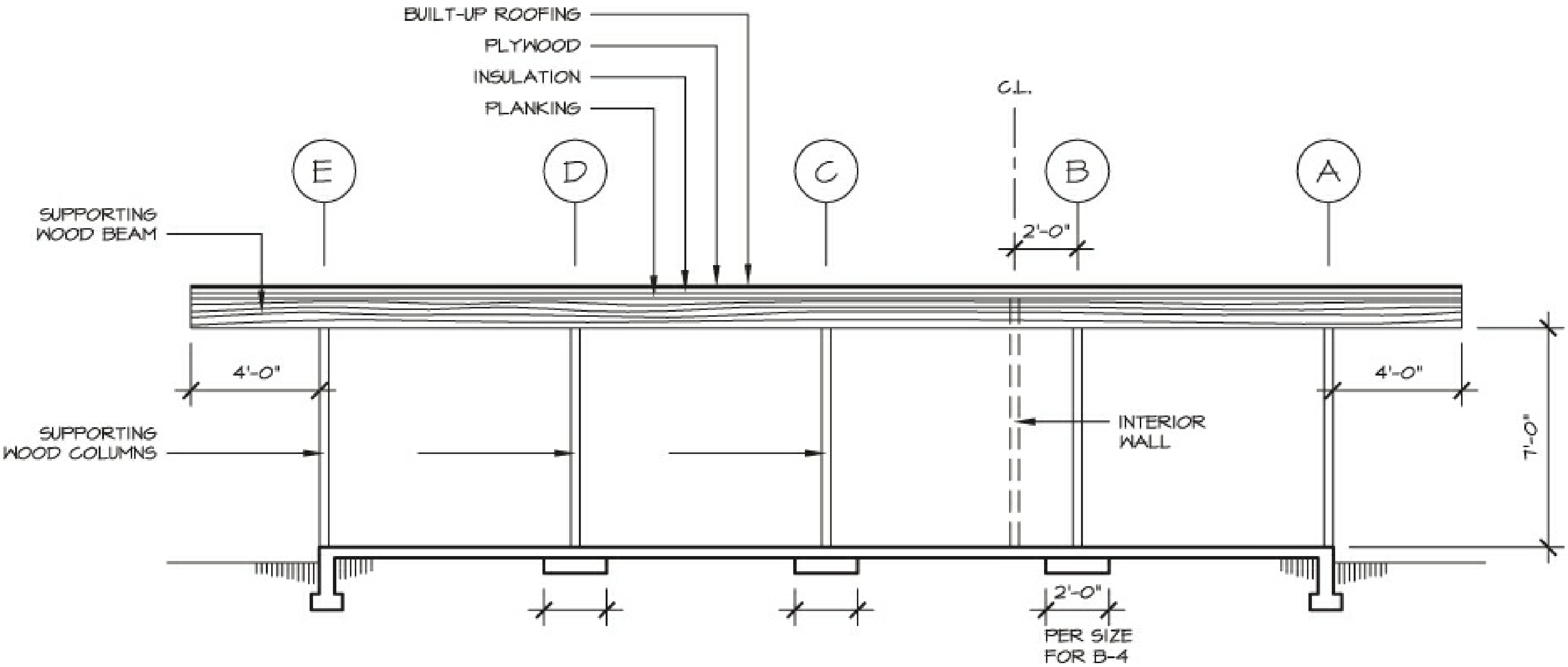
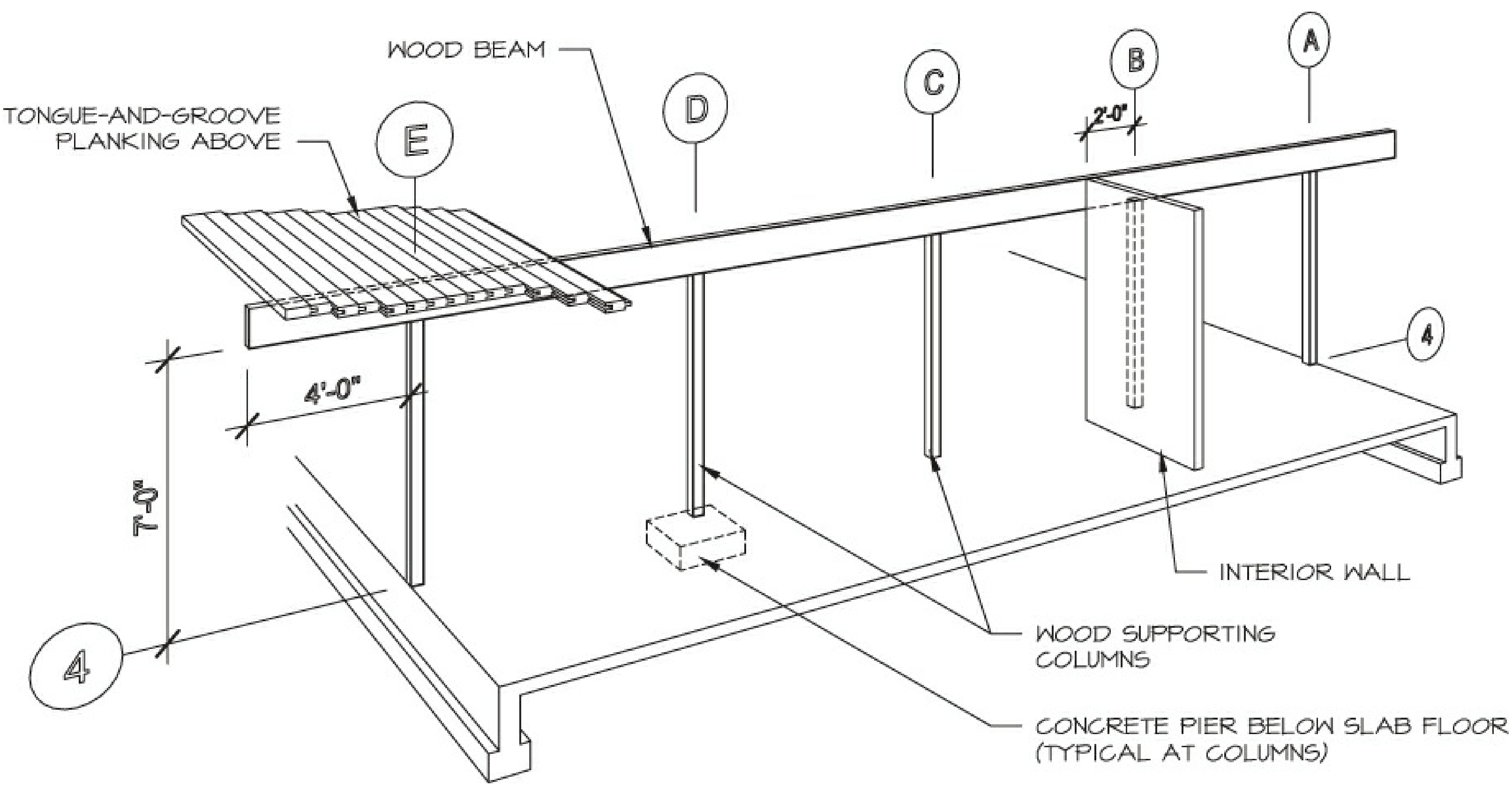


Figure 5.8 Partial drawing of Figure 5.7.

Building Section. The next major item to consider and analyze is the building sections for the post…and…beam wood framing method. For this project, the architect decided to use tongue…and…groove planking spanning over the exposed beams, which are to be spaced 8′ center to center. Nailed directly over the tongue…and…groove planking will be one layer of 3/8″ exterior…grade plywood. To meet energy conservation standards, one layer of insulation board, such as urethane, will be applied over the plywood and will be the substrate for the application of a built…up roofing system. See Figure 5.9. This building section is viewed along the matrix axis line. Figure 5.10 depicts pictorially a view along the matrix line.



[Figure 5.9] Building section on axis 4.



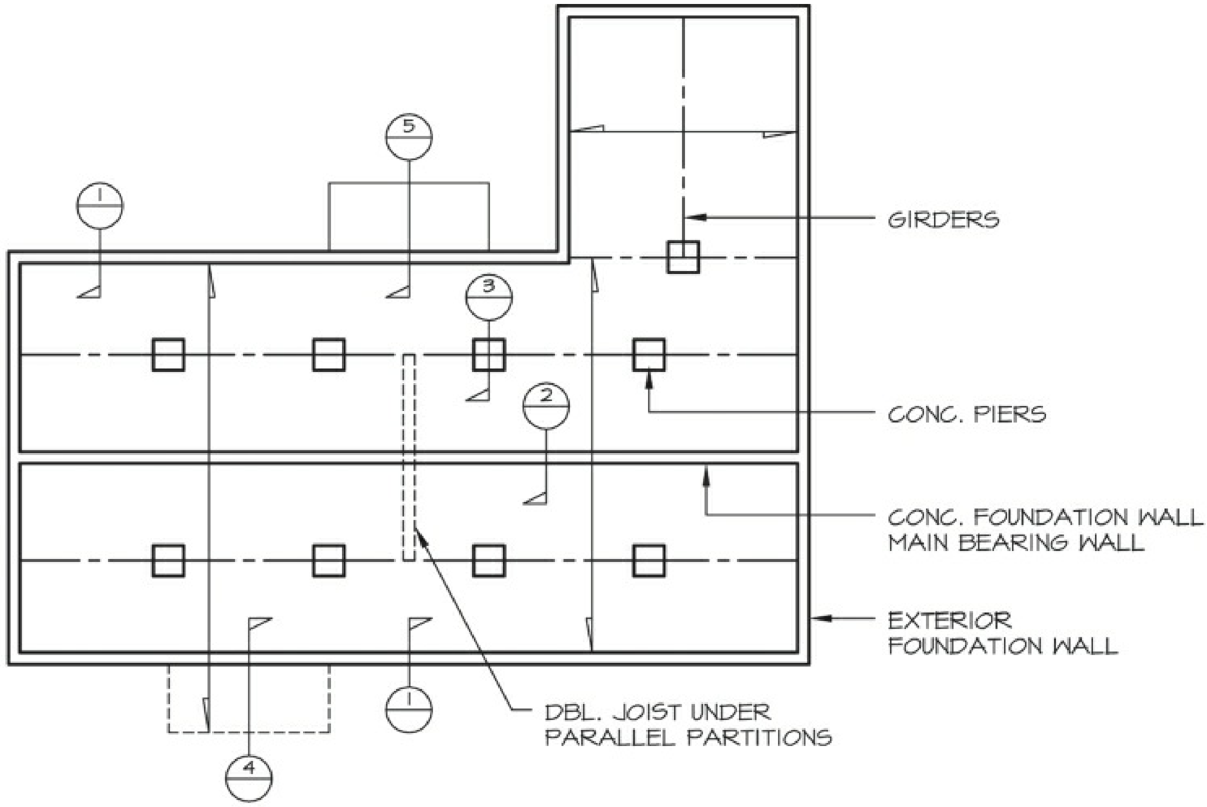
[Figure 5.10] Pictorial view along matrix 4.

WOOD FLOOR SYSTEMS

Sawn Lumber Floor Joist System

The most conventional wood floor systems use sawn lumber floor joists as the supporting structural members. For a single…story residence, these members may be 2 × 6 or 2 × 8 joists. Although lumber members are named 2 × 6 or 2 × 8, they typically measure 1½″ ×

3½″ and 1½″ × 5½″, respectively. This is due to the milling process of the lumber manufacturer. Notice the inch mark when calling out the actual size of the member. This actual size is often called the **net size** and is a common result for sawn lumber. The dimensions of lumber selected will depend on the live and dead load and the span of the joists. Plywood of varying thickness is used as a subfloor for supporting the finish floor material. The spacing of the floor joists is usually 16″ on center. The structural members are supported by the exterior perimeter concrete foundation walls, and the intermediate supports in the interior include the concrete foundation walls and/or wood girders and concrete piers. See Figure 5.11.



5
1
3
2
4
1
GIRDERS
CONC. PIERS
CONC. FOUNDATION WALL
MAIN BEARING WALL
EXTERIOR
FOUNDATION WALL
DBL. JOIST UNDER
PARALLEL PARTITIONS

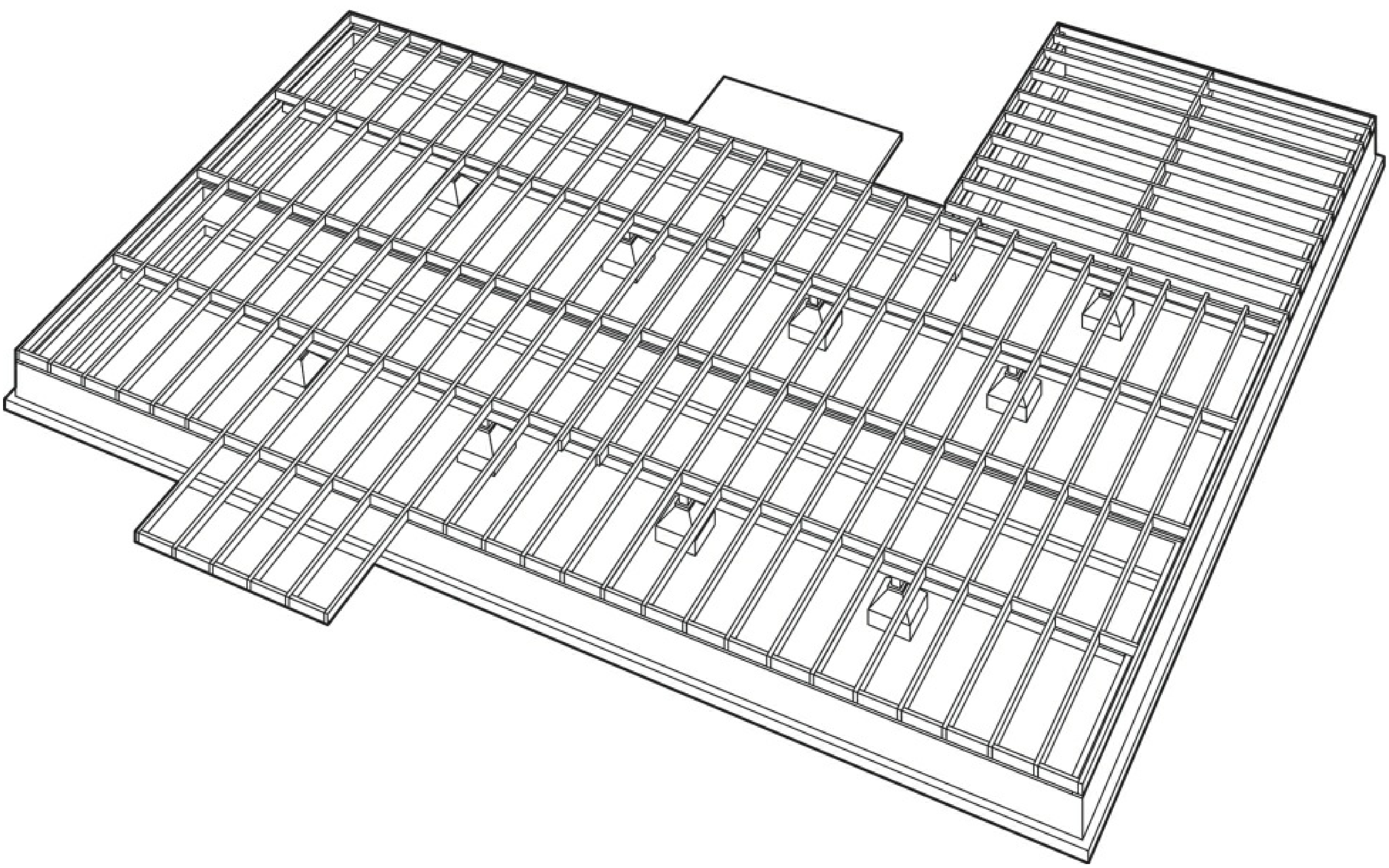


Figure 5.11 Foundation plan: Wood floor joist system.

The advantages of utilizing a sawn lumber floor joist system are:

1. Greater span length relative to the size of the joist
2. Requires fewer internal supporting walls and girders
3. Capable of providing floor joist cantilevers
4. Permits insulation material to be placed between the joist members
5. Allows rewiring, making plumbing modifications, or renovating under floor areas
6. Accommodates sloping lots
7. Levels irregular floor elevations or sloping floors

Sawn lumber floor joist systems are not appropriate:

1. In regions highly susceptible to termite infestation and dry rot
2. For buildings that require a minimum amount of noise transmission
3. In buildings desiring a lower silhouette
4. Where a crawl space must be ventilated relative to grade
5. If rats, other wild animals, or other pests may access the crawl space
6. When sustainability is a concern

Construction Principles

1. Ensure that the wood members are not in direct contact with the concrete.
2. Provide recommended under…floor clearances from the soil.
3. Select floor joist sizes that will minimize deflection or floor movement.
4. Provide proper flashing to protect wood members from possible moisture.
5. Provide recommended under…floor ventilation.
6. Ensure that the floor is rat…proofed.

Detail 1, as designated on the foundation plan in Figure 5.11, is an isometric drawing of an exterior concrete foundation wall utilizing a wood floor joist and a plywood subfloor. Note the exterior foundation vent for the under…floor ventilation. See Figure 5.12.

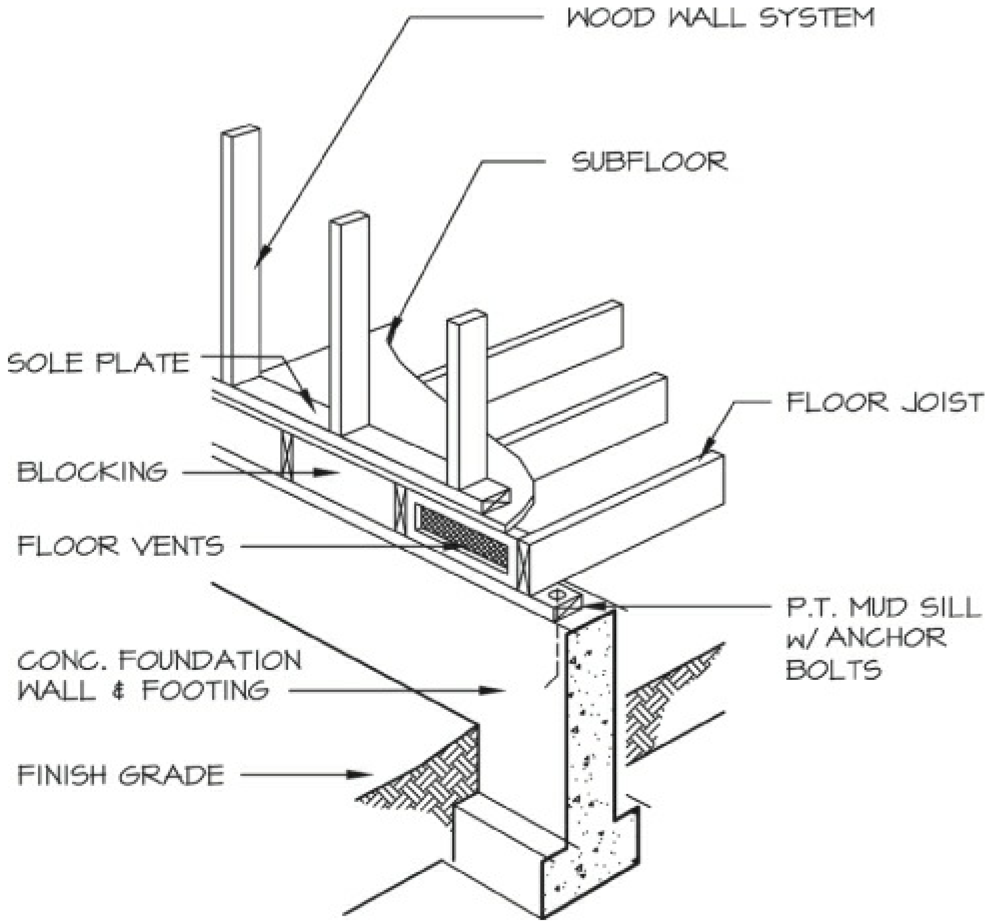


Figure 5.12 Exterior foundation wall with wood floor joist.

Internal Load‗Bearing Foundation. Internal load…bearing foundation assemblies are designed to support heavy loads from the floor system, load…bearing walls, and ceiling and roof loads. Such a foundation assembly may be designed as a concrete wall and footing similar to that in Figure 5.12, or with the use of wood girders and concrete piers. The size of the wood girders and the spacing of the concrete piers are predicated on the amount of structural loading they are required to support. Whenever possible, it is recommended that the wood girders be located directly beneath the load…bearing wall. It is good practice not to extend floor joists to their maximum span, because this approach may cause deflection or movement in the floor system. It is also good practice to include additional rows of girders and piers to provide a stiffer floor system. Figure 5.13 shows an internal pier and wood girder assembly. Note the required solid blocking between the floor joist and its placement directly above the girder and under the wall partition.

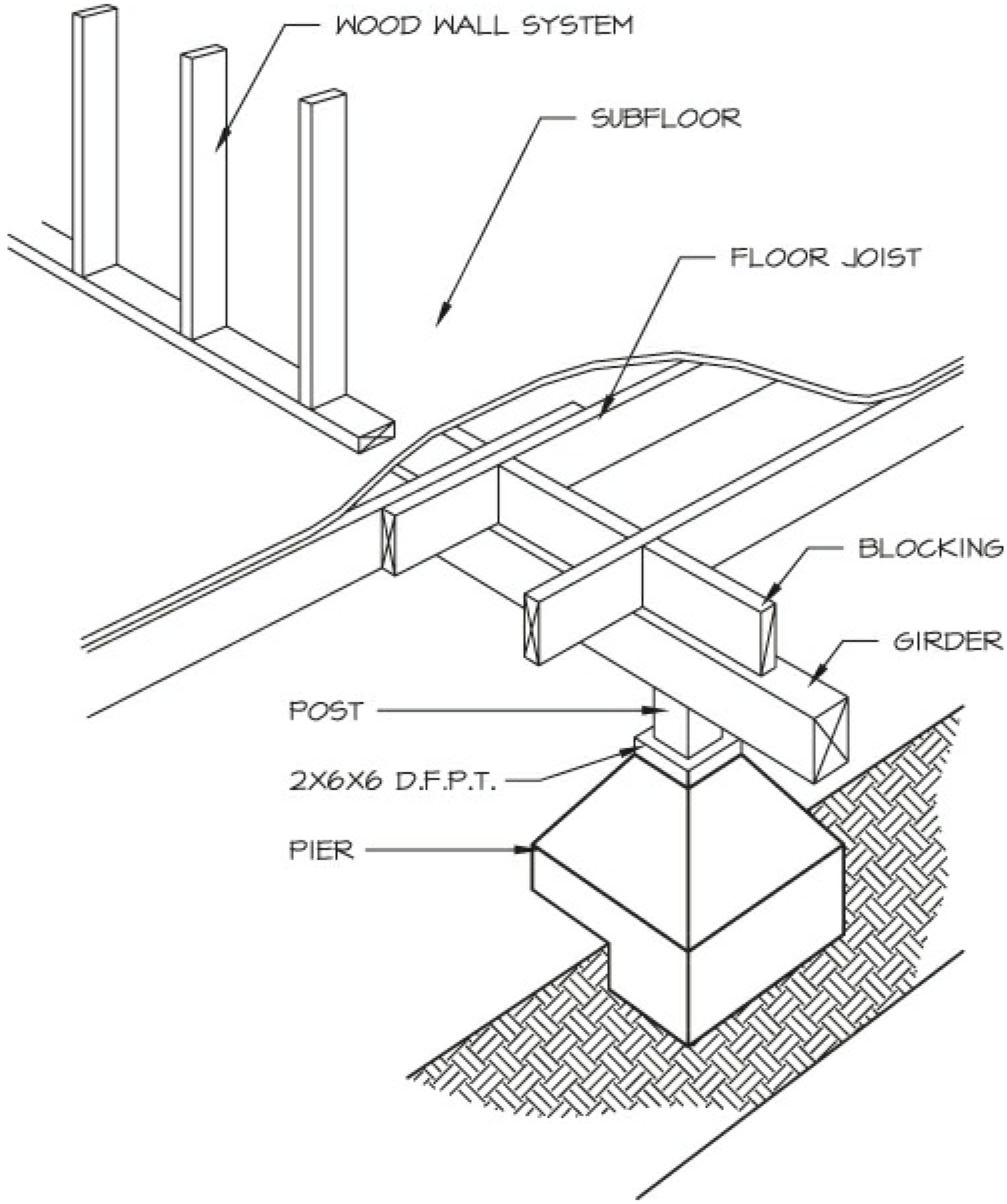


Figure 5.13 Internal pier and girder assembly.

Moisture Protection. As mentioned in the list of construction principles for a wood floor system, it is paramount to protect wood members against moisture. Moisture can cause dry rot, swelling, and buckling of wood members. One method of deterring moisture is to provide an adequate sheet…metal flashing system in areas subject to water seepage.

Detail 5 in Figure 5.11 illustrates a recommended sheet…metal flashing assembly positioned between a concrete porch and a wood floor system. See Figure 5.14.

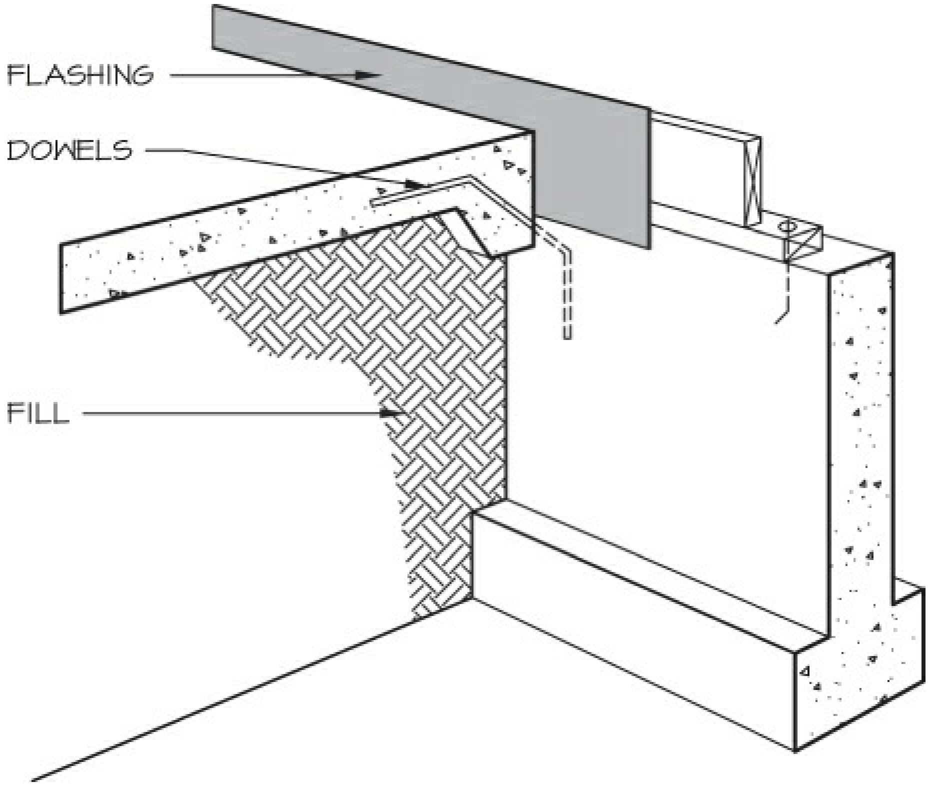
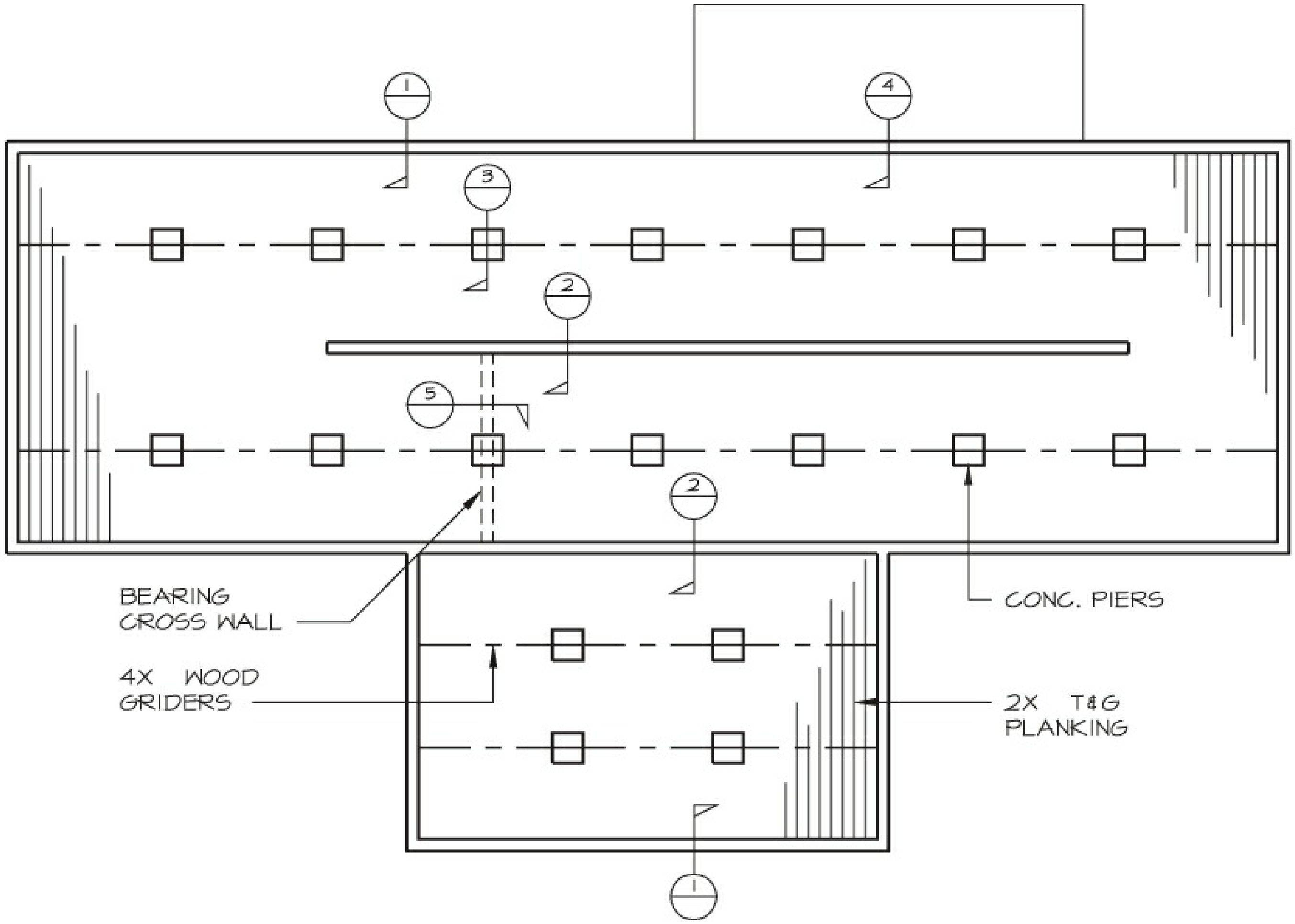


Figure 5.14 Flashing assembly (porch slab and wood floor).

Wood Plank Floor System

Another wood floor system frequently used is called tongue…and…groove **planking**. This system uses 2 × 6 or 2 × 8 wide wood members. These members, with high stress capabilities, are used to span over wood girders and concrete foundation walls. This system requires additional rows of girders and piers because the span for the 2″ planking is generally limited to spans from 4′ to 5′.

Figure 5.15 illustrates a wood floor system for a one…story residence utilizing girders as the support for 2″ tongue…and…groove planking. It is recommended that plywood be applied directly over the 2″ planking members for the purpose of providing a sub…base for the finish floor materials, as well as developing a tie between the various members. Whenever possible, it is recommended that concrete foundation walls and/or girders be positioned directly under paralleling walls. When bearing walls are parallel with the planking members, it will be necessary to provide a 4× wood girder in the floor system for support. The depth of the girder is governed by the load factor from the wall above and other load…carrying members. Note that the bearing cross…wall member in Figure 5.15 will be installed for support of the load…bearing wall. An isometric drawing depicting the exterior foundation wall for the tongue…and…groove floor system is shown in Figure 5.16.


1
4
3
2
5
2
BEARING
CROSS WALL
CONC. PIERS
4X WOOD
GRIDERS
2X T&G
PLANKING
1

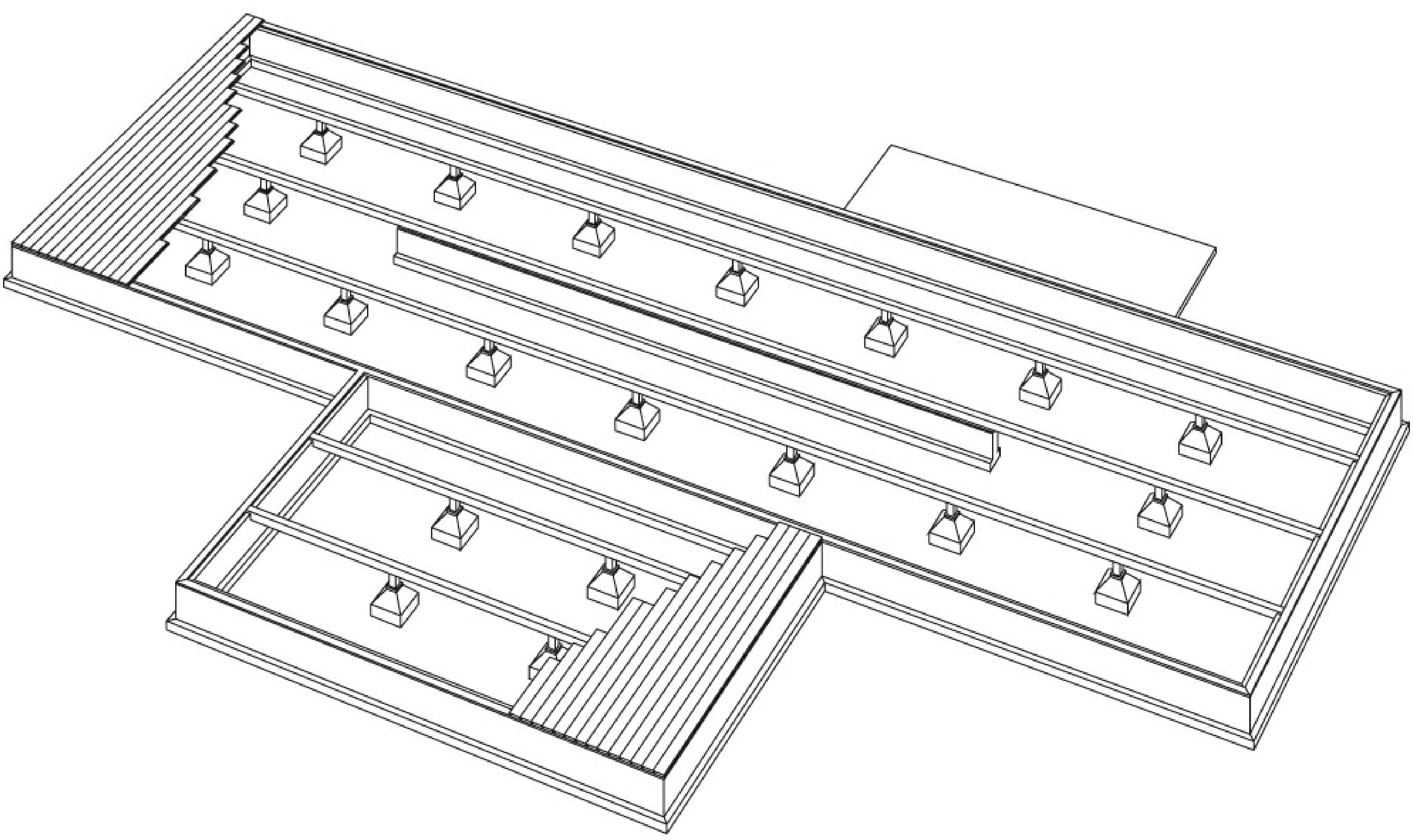


Figure 5.15 Foundation plan: 2”…thick tongue…and…groove planking.

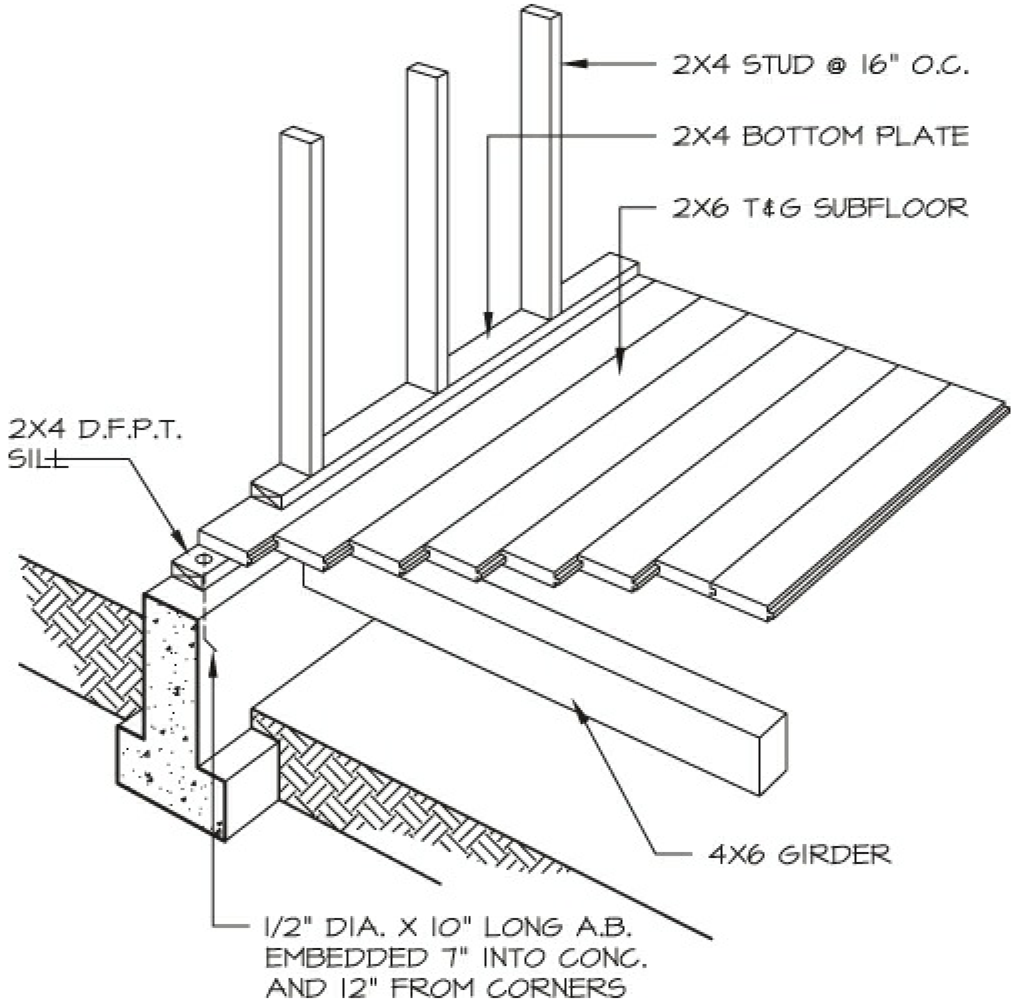


Figure 5.16 Exterior foundation wall with 2”…thick tongue…and…groove planking.

The advantages of using a tongue…and…groove floor system are:

1. It provides a stiffer floor with the recommended spacing of girders.
2. It provides a lower building height silhouette, because the added height of the floor joists is eliminated.
3. It has a lower noise factor than a plywood floor system.
4. It provides a more rigid subfloor for finish floor materials such as ceramic or concrete tiles.
5. Tongue…and…groove planking is available in greater thickness, which can be used when longer spans are required.

The disadvantages of using a tongue…and…groove floor system are:

1. Shorter spans will require additional foundation walls, girders, and piers.
2. The system is not conducive to the use of floor cantilevers.
3. The system is susceptible to termite infestation and dry rot (in regions where these problems are endemic).
4. The system does not allow the development of floor beams. Conventional floor joist

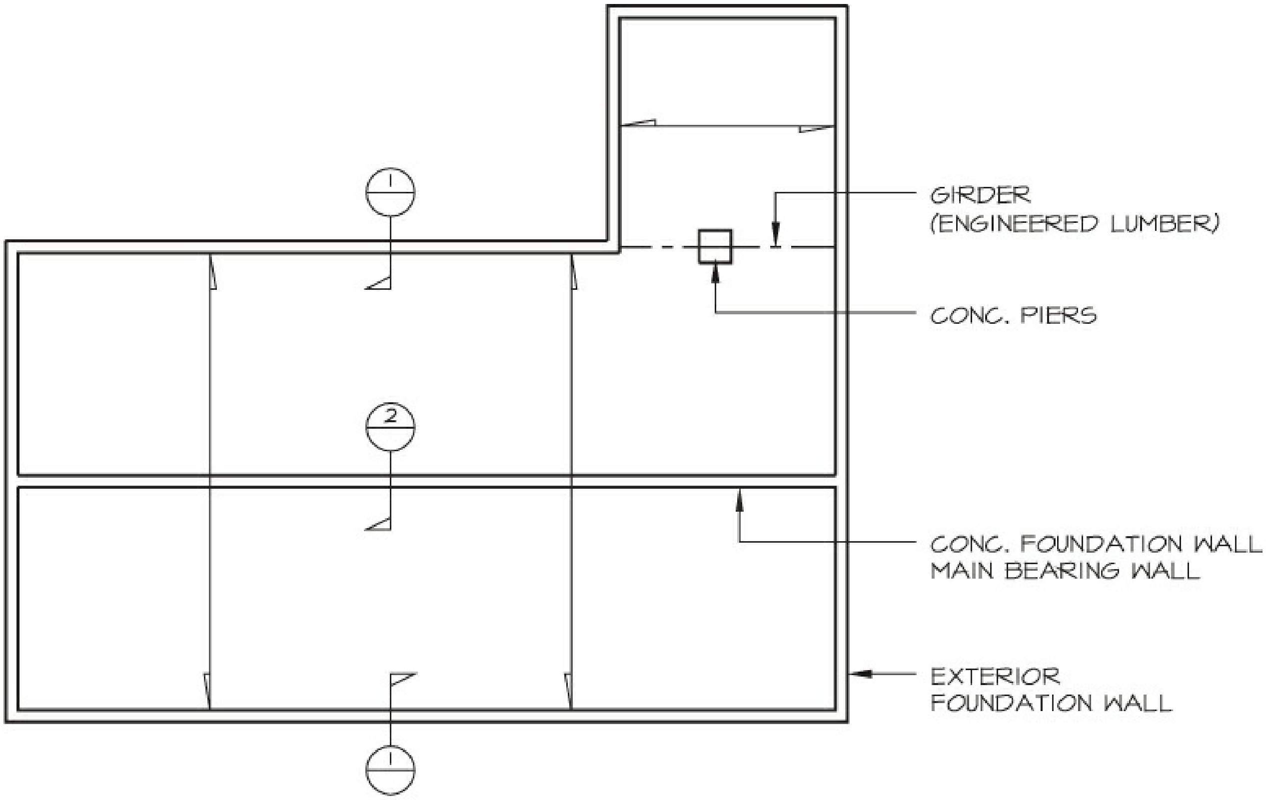
systems may combine a number of floor joists for the purpose of creating a structural beam.

5. The system does not provide space for blanket insulation.
6. Sustainability is a concern.

Engineered Lumber Wood Floor System

The use of engineered lumber floor joists has proven to be very successful in wood floor systems. Engineered lumber or wood is manufactured by adhering wood strands, veneers, fibers, or particles together to manufacture a new product that can be made to meet certain criteria of strength or shape. Engineered floor joists have been approved by all major building codes.

To see the structural capabilities of this floor joist system, compare the span lengths in the foundation plan illustrated in Figure 5.11 (sawn lumber floor joists) with those of the engineered lumber floor joists shown in Figure 5.17. Two rows of girders and piers have been eliminated from the foundation plan in Figure 5.17 because of the greater strength and load…bearing capacity of the engineered lumber. Other engineered lumber wood members that may be used in a wood floor system are girders and floor beams. These members are developed and fabricated with the use of laminated veneer lumber. The laminated members provide a high allowable bearing stress that is accepted by all major building codes, and are consistent in size and performance. They also reduce the problems of splitting, warping, and checking. The size of these members may range from 1½″ to 7″ in thickness and standard depths may range from 7¼″ to 24″.


1
GIRDER
(ENGINEERED LUMBER)
CONC. PIERS
2
CONC. FOUNDATION WALL
MAIN BEARING WALL
EXTERIOR
FOUNDATION WALL
1

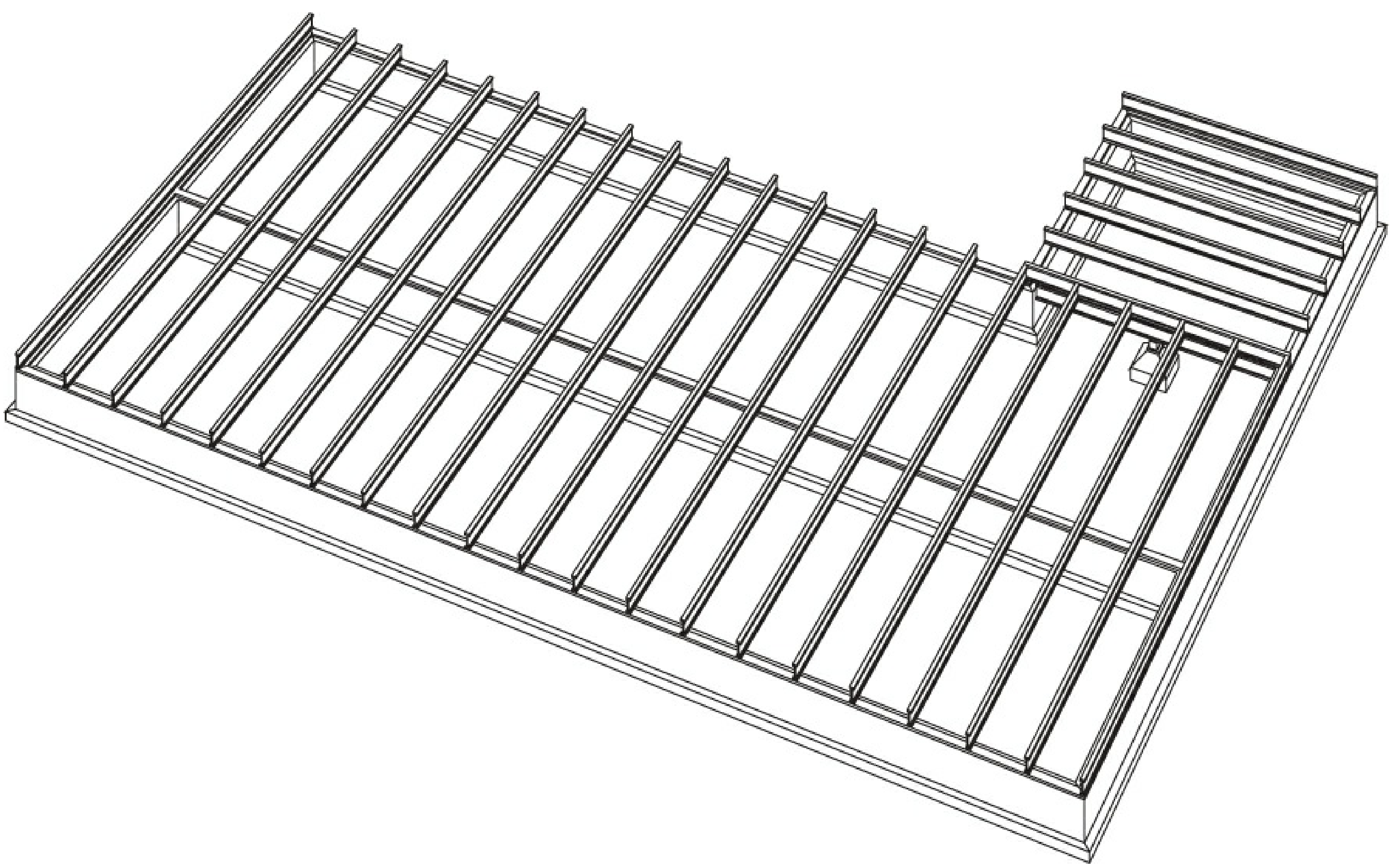


Figure 5.17 Engineered lumber floor joist.

An example of the aforementioned engineered lumber joist, illustrating its shape and fabrication components, is shown as an isometric drawing in Figure 5.18. Sizes and structural capabilities will vary among manufacturers of engineered lumber.

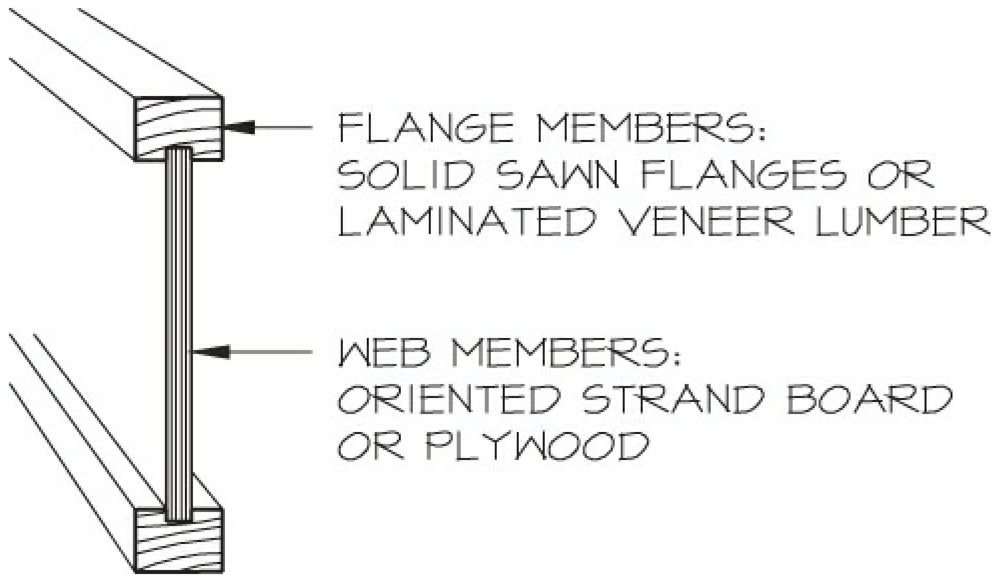


Figure 5.18 Engineered lumber floor shape.

Figure 5.19 is a three…dimensional drawing segment of the foundation plan in Figure 5.17, showing the concrete footing, engineered lumber floor joist, engineered plywood subfloor, and wood stud walls.

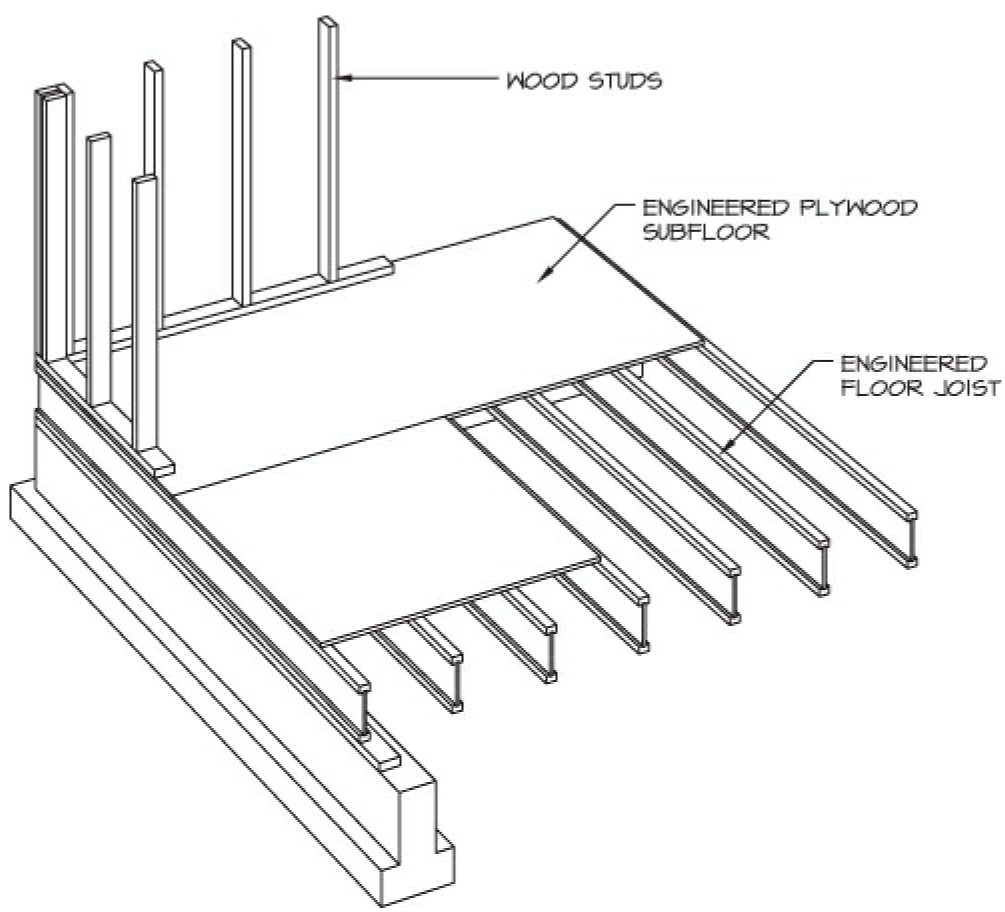


Figure 5.19 Engineered lumber floor system.

The advantages of an engineered lumber wood floor joist system are:

1. Floor joist sizes are uniform.
2. Light weight allows for easier handling on the job.
3. Splitting, checking, warping, and crowning are eliminated.
4. System has greater structural capabilities.
5. Better construction quality of material (no knots).

The disadvantages of an engineered lumber wood floor joist system are:

1. There are limitations on cutting the members in the framing process.
2. There are restrictions on the location in the web sections where holes may be cut.
3. Proper care must be taken to protect these joists prior to installation.
4. The system creates a higher building silhouette because of the increased depth of the joist.
5. One cannot taper the floor joists.

WOOD WALL SYSTEMS

Framing Systems

The two most conventional types of wood stud wall framing systems used in construction are the balloon framing system and the Western or platform framing system. The main differences between these two systems are at the intersection of the second…floor framing assembly and the wall.

Balloon Framing

In the construction of two…story structures, the balloon framing system uses continuous wall studs from the first…floor level up to the roof assembly. The second…floor supporting members are then framed to the continuous studs. Stud sizes are 2 × 4 or 2 × 6 at 16″ center to center. 2× blocking is fitted to fill all openings to provide fire stops and prevent drafts from one space to another.

Wood or metal members are attached securely at a 45° angle to the top and bottom of the studs and provide horizontal bracing for the walls. In areas subjected to strong lateral forces, sheathing is used for horizontal bracing. Balloon framing is not utilized in all parts of the country; refer to the local codes for allowable use. See Figure 5.20. The use of plywood or **oriented strand board (OSB)** panels may be determined by the governing building code or the structural engineering requirements. This system has a minimum amount of vertical shrinkage and vertical movement and may be used with brick veneer or cement plaster exterior finishes.

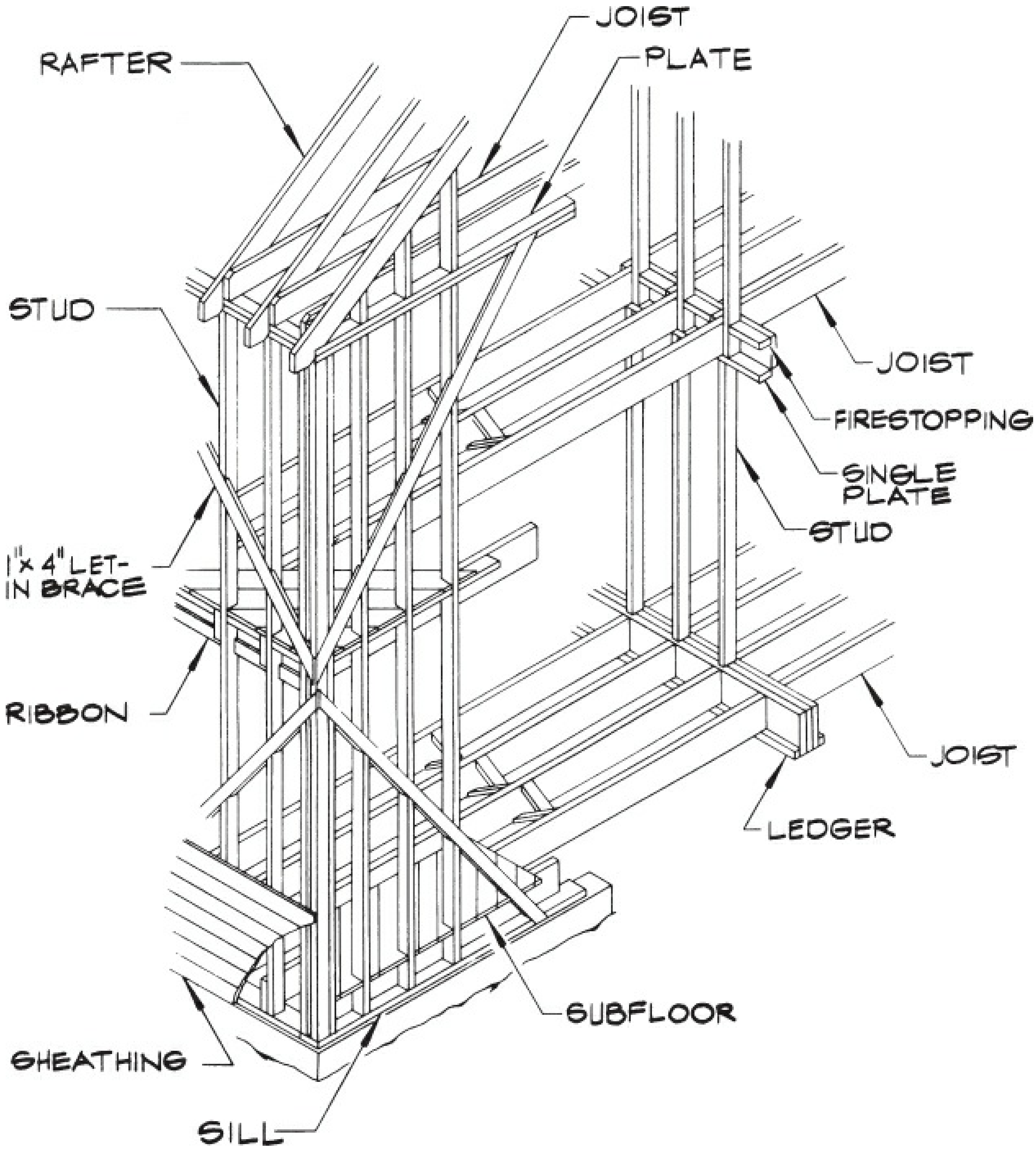


Figure 5.20 Balloon‐frame construction.

(Courtesy of American Wood Council, Leesburg, VA.)

Western or Platform Framing

Western or platform framing uses a different procedure. The lower floor walls are assembled first, and then the supporting floor members and subfloor for the upper floor are framed. The upper subfloor and floor joists provide a platform for assembling the upper‐floor walls, ceiling joists, and roof framing. The walls are framed with 2 × 4 or 2 × 6 studs at 16″ center to center. Required blocking is 2″ thick and is fitted to provide stiffness to the joist.

Solid sheathing, diagonal braces, plywood, or OSB panels may provide lateral bracing. Building code requirements, regional differences, and structural engineering calculations

may determine the type of lateral bracing. See Figure 5.21.

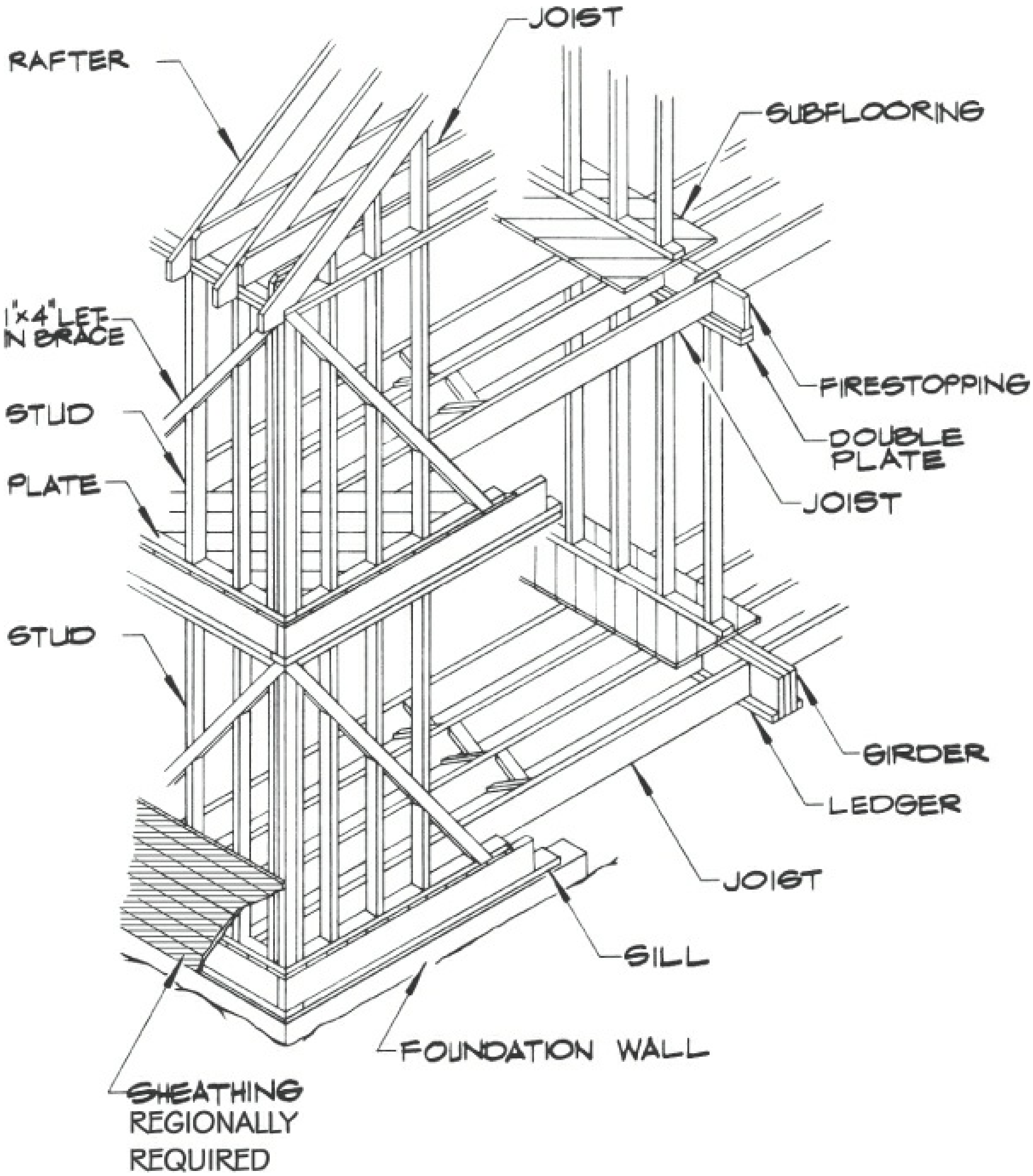


Figure 5.21 Western or platform framing.

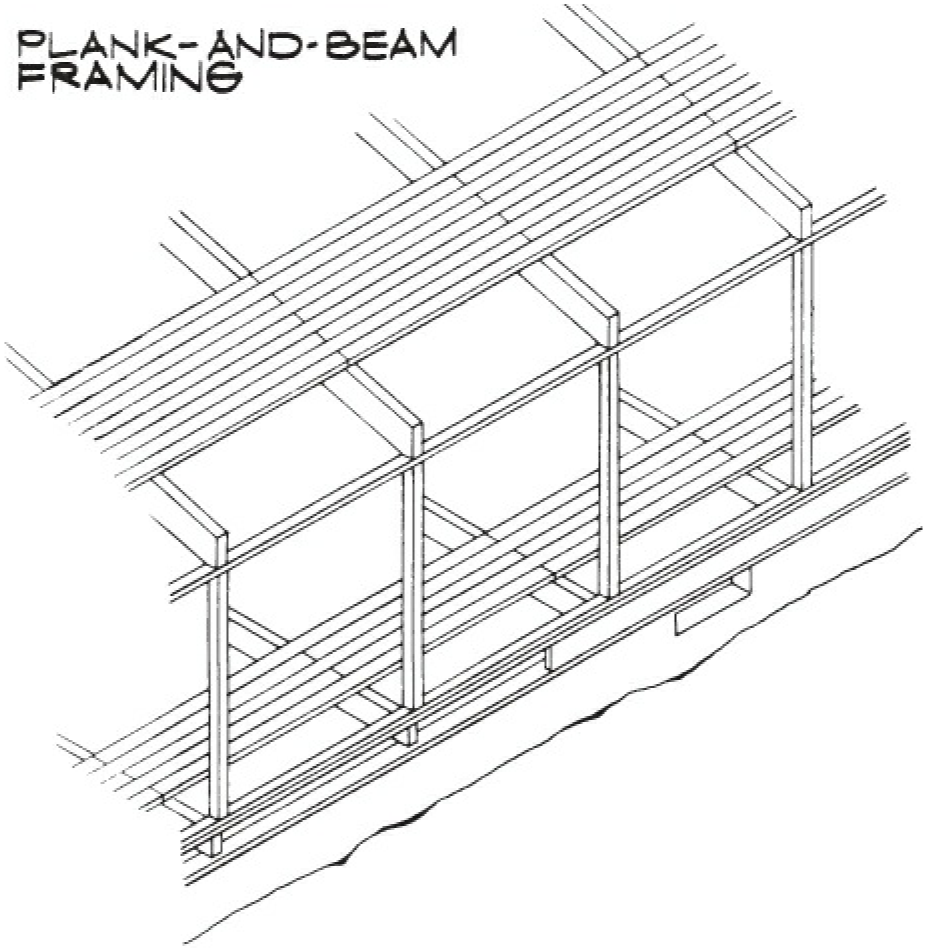
(Courtesy of American Wood Council, Leesburg, VA.)

Post…and…Beam Framing

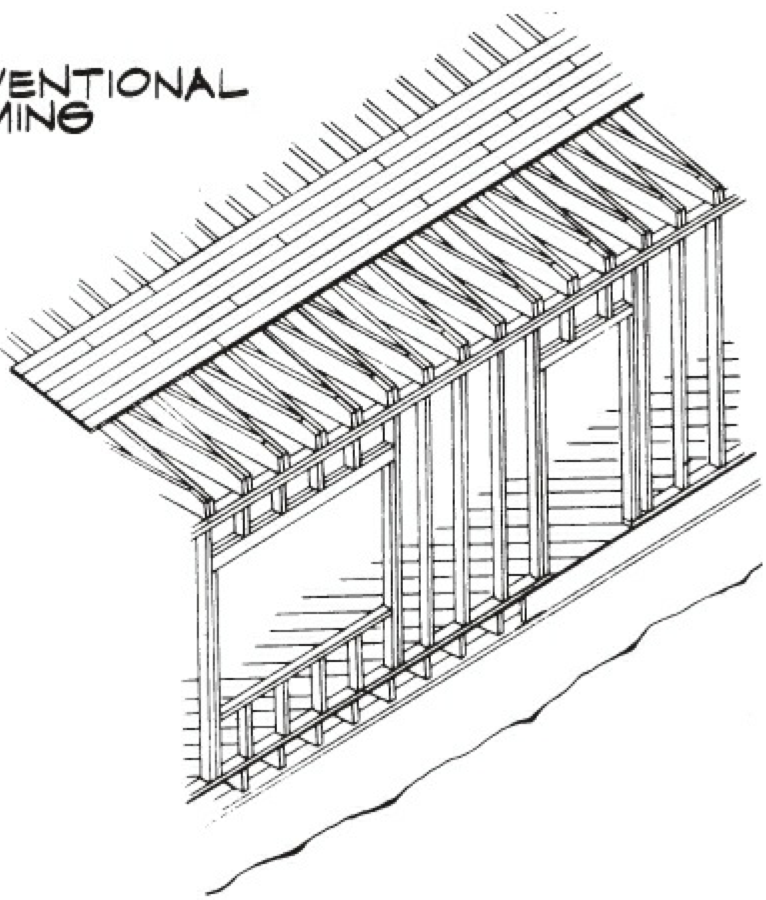
A third method for framing wood structures is the post…and…beam system. Less common than platform and balloon framing, this method uses a post…and…beam spacing that allows the builder to use 2× roof or floor planking. See Figure 5.22. For the best use of this system, a specific module of plank…and…beam spacing must be established. Supplementary bracing is placed on the exterior walls, with options similar to those used in conventional framing systems. You must provide a positive connection between the post and the beam and secure the post to the floor. Different types of metal framing connectors may be used to satisfy these connection requirements. If metal framing

connectors are undesirable for aesthetic reasons, then steel dowels may be utilized at the post…to…beam connection and the post…to…floor connection. See Figures 5.23 and 5.24. Because fewer pieces are used in this system, special attention to post…to…beam connections and connections to other members should be given in detailing these conditions. With proper detailing, such connections will securely fasten components of the building together and act as a unit to resist any external forces.

PLANK-AND-BEAM
FRAMING



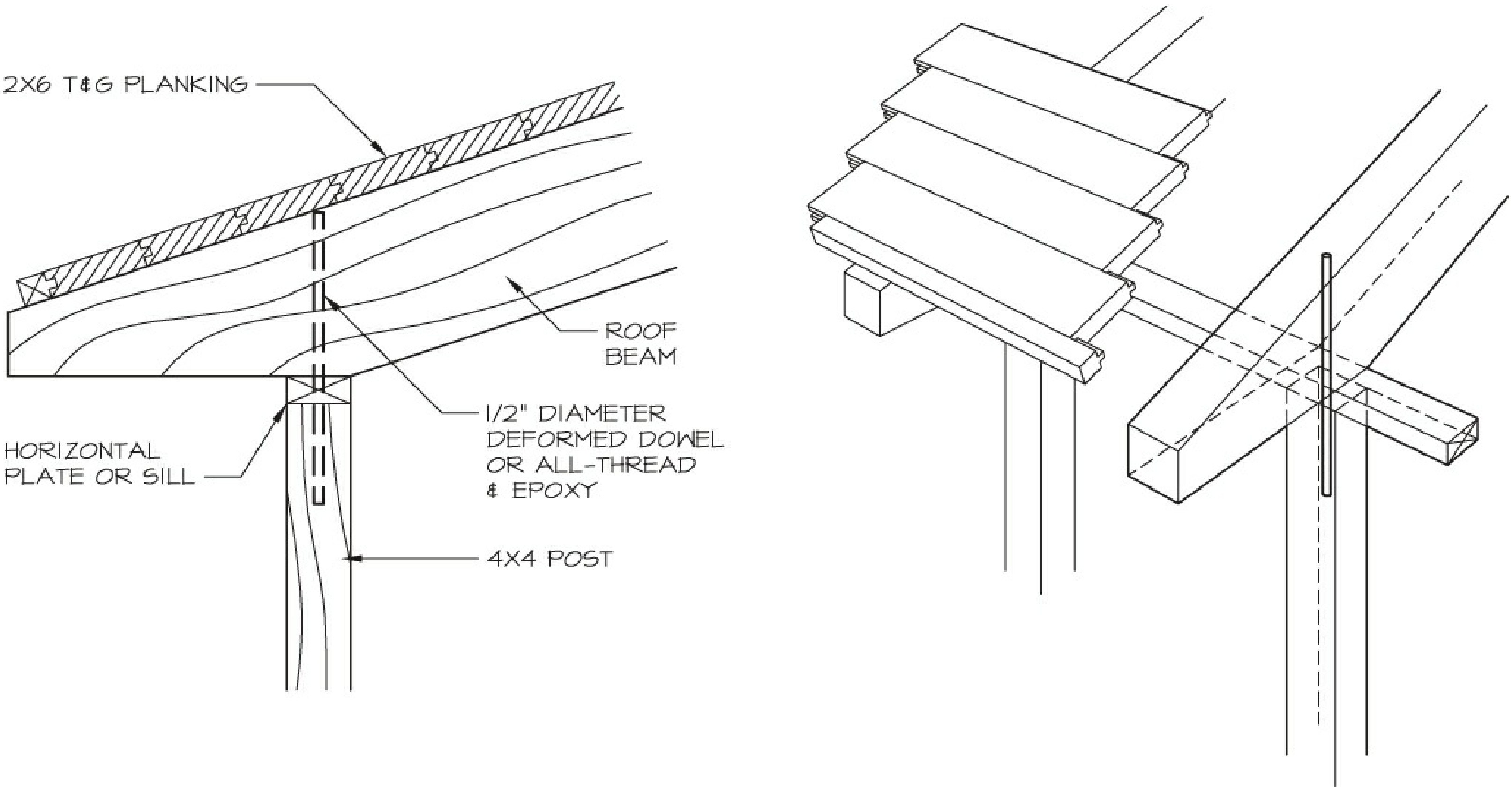
CONVENTIONAL
FRAMING



COMPARISON OF PLANK-AND-BEAM SYSTEM WITH CONVENTIONAL FRAMING

[Figure 5.22](#) Pictorial comparison of plank…and…beam framing with conventional framing.

(Courtesy of American Wood Council, Leesburg, VA.)



[Figure 5.23](#) Post…to…beam connection.

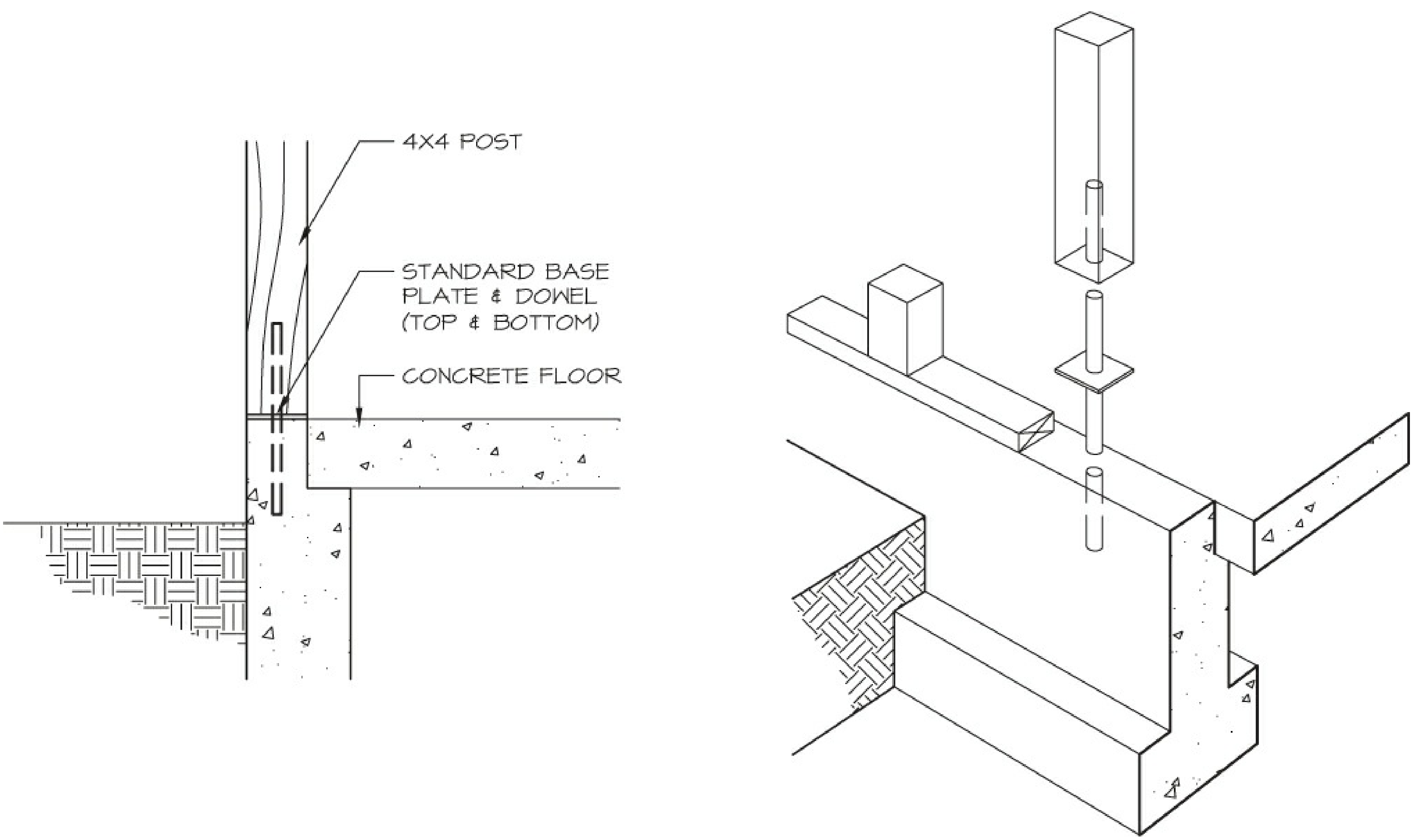


Figure 5.24 Post–to–foundation connection.

Engineered Lumber Wall Systems

Engineered lumber sheathing panels are used in wood stud wall construction to strengthen and stabilize exterior and interior walls. Engineered sheathing panels used for exterior walls should be protected with building paper, wood siding, or other types of exterior cladding to protect the panels from damage caused by water or other moisture conditions. These panels are fabricated in sizes ranging from 4′ × 8′ to 4′ × 9′ and 4′ × 10′. Panel thickness can range from 3/8″ to 11/8″, and panels are manufactured using plywood or OSB. See Figure 5.25.

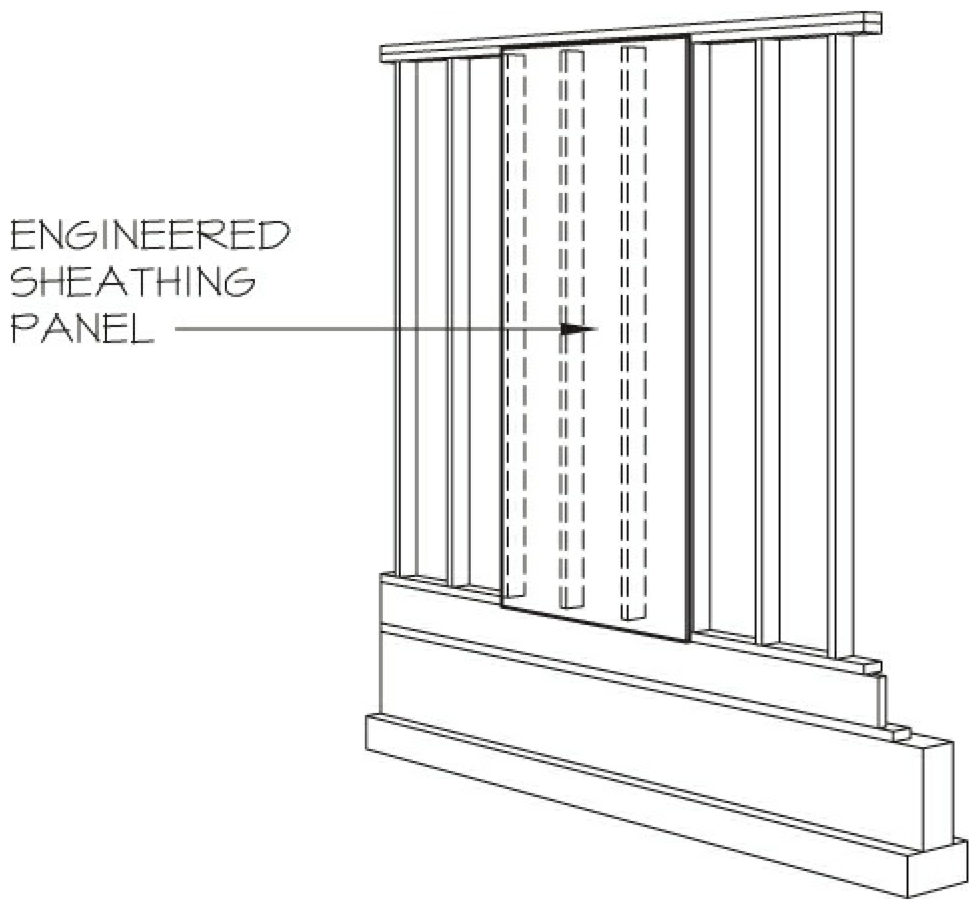


Figure 5.25 Engineered sheathing panel.

WOOD ROOF SYSTEMS

Roof Materials

The principles underlying wood roof systems, and the construction methods used in developing these systems, may depend on the finish roof material and the requirements of its application. The following are examples of finish roof materials used over roof framing systems:

1. Wood shingles or shakes (can be fire treated)
2. Asphalt shingles

3. Clay or concrete tiles
4. Built…up composition, gravel surface, and torch down
5. Aluminum, copper, stainless steel, or galvanized metal
6. Standing seam or corrugated metal
7. Green roof

Wood Roof System Utilizing Sawn Lumber

Sawn lumber members of various dimensions have been used for the construction of wood…framed roofs. Utilizing these members can provide more on…the…job flexibility for roof systems because members can be cut and fitted to the varying conditions that may occur during the roof framing stage. Members required for blocking, bracing members, studs, plates, and others are used to fit the jobsite conditions. An example of sawn lumber roof framing is shown in Figure 5.26. The use of sawn lumber members affords the architect greater latitude in designing the external projections of a roof system, including eave and rake designs. Examples of eave designs are shown in Figures 5.27 and 5.28.

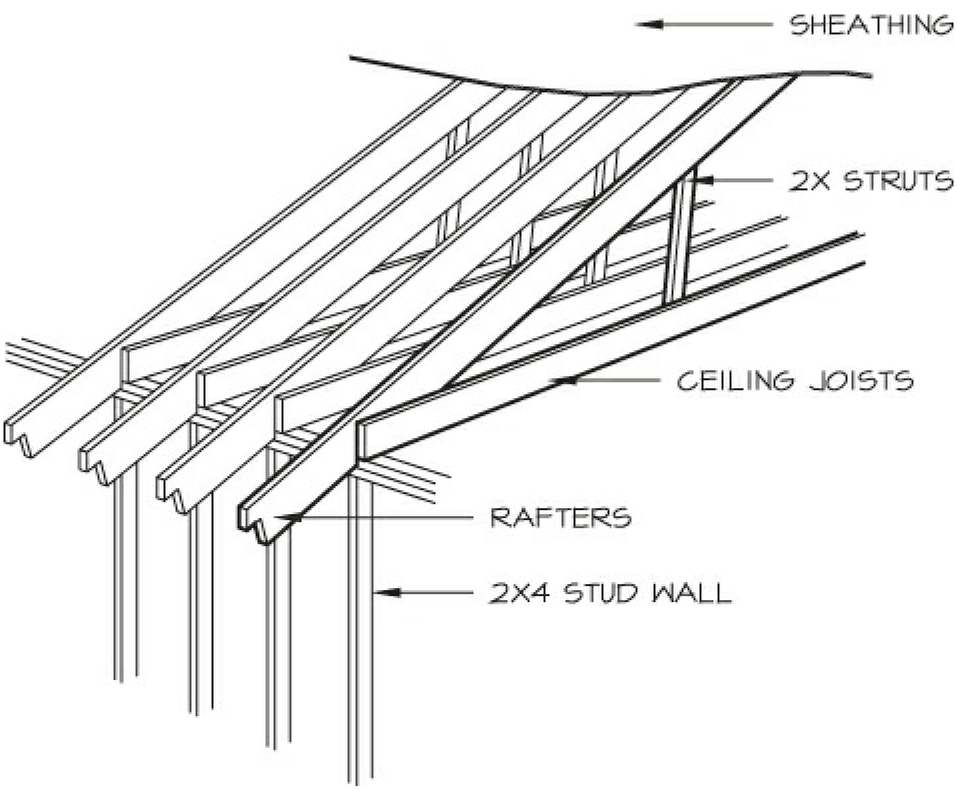


Figure 5.26 Sawn lumber roof system.

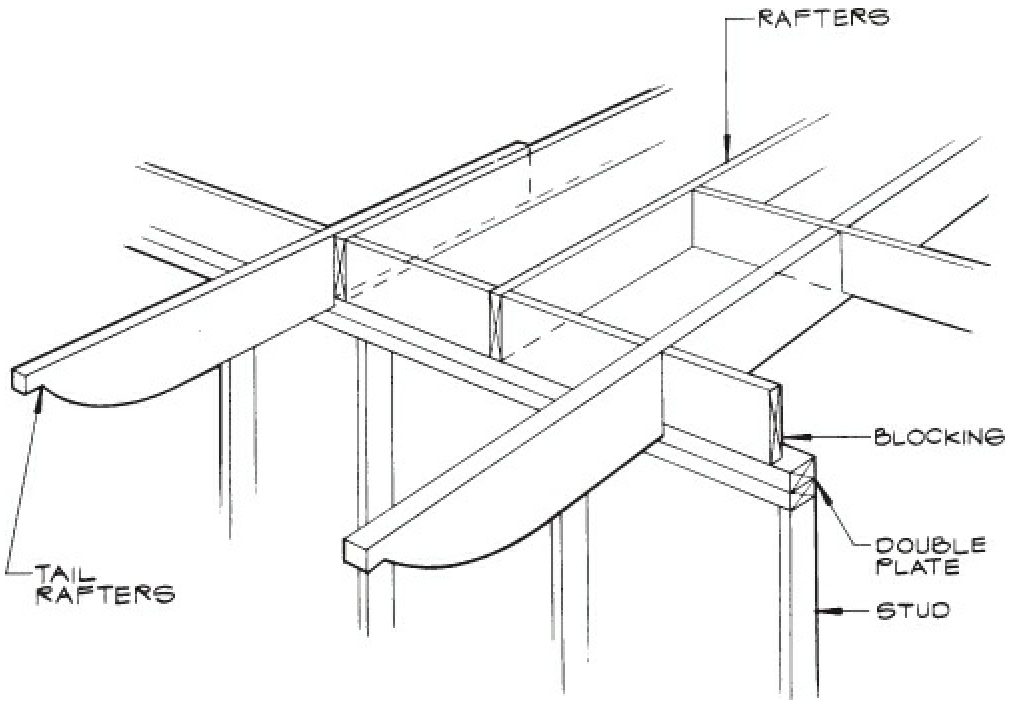


Figure 5.27 Pictorial view, eave detail.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

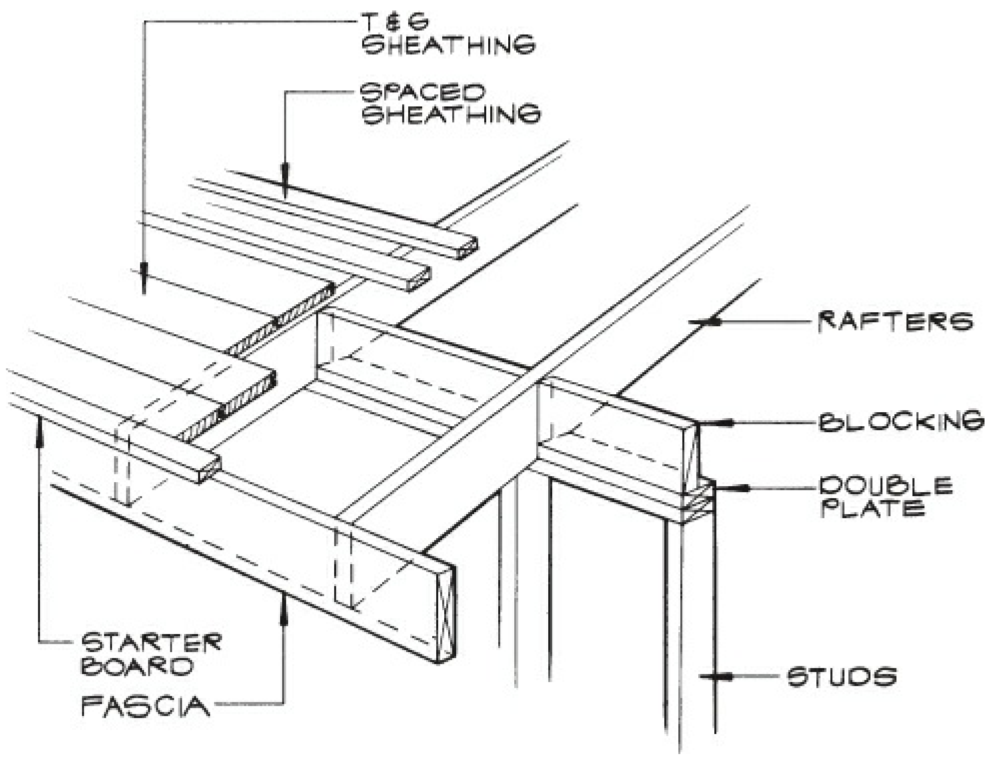


Figure 5.28 Pictorial view, eave detail.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Planking

The term *planking* is used to refer to members that have a minimum depth of 2″ and various widths. The edges of these members are normally tongue and groove. Using such edges enables a continuous joining of members so that a concentrated load is distributed

onto the adjacent members. See Figure 5.29.

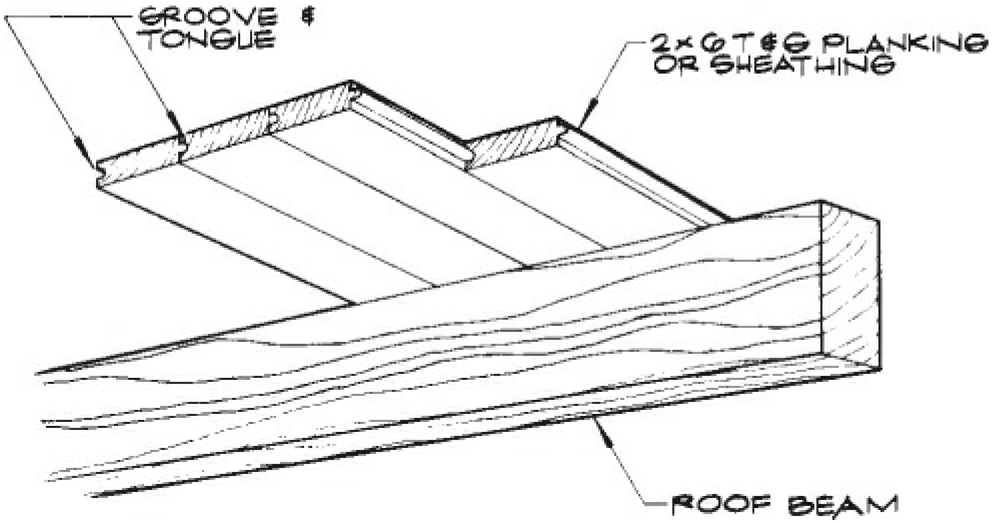


Figure 5.29 Pictorial view of roof planking.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition., © 2003 by John Wiley & Sons, Inc.)

Plank…and…Beam and Heavy Timber Roof Systems

The plank…and…beam roof system uses heavy wood beam members greater than 2″ in thickness to support roof planking and the finish roofing material. The main supporting wood beam members normally have a modular spacing, such as 6′ to 8′ on center. The spacing of these members is determined by the weight of the finish roofing materials. In general, the architect selects this system for use where he or she wishes to expose the roof structural system for reasons of aesthetics or code requirements. For roof members that must satisfy heavy timber construction requirements, the roof planking must have a thickness of not less than 2″ and must provide a tongue…and…groove or splined connection. The main supporting members must not be less than 4″ in width and not less than 6″ in depth. All supporting wood columns must be at least 8″ in any dimension. See Figure 5.30.

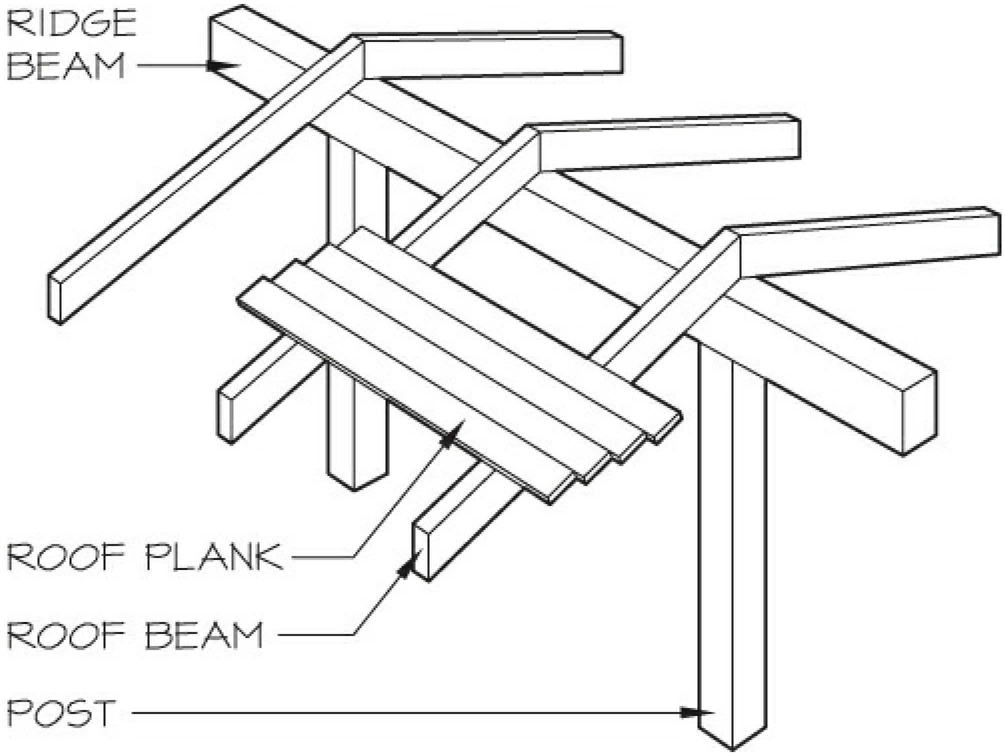


Figure 5.30 Plank…and…beam roof system.

Wood Truss Roof System

Wood roof trusses are available in many sizes, shapes, and lengths. Wood roof trusses are generally fabricated by a manufacturer and delivered to the building site. Trusses are selected according to the manufacturer's stipulated engineered design criteria for the various weights of materials that the trusses must support. They can be custom manufactured to the desired shape and are a good choice for both budgets and for sensitivity to the environment. One method of utilizing a wood truss roof system is to place the trusses on a dimensional module spacing that allows the intermediate roof supporting members to span the trusses. See Figure 5.31. An alternative method is to utilize truss members at a 16″ or 24″ center…to…center spacing.

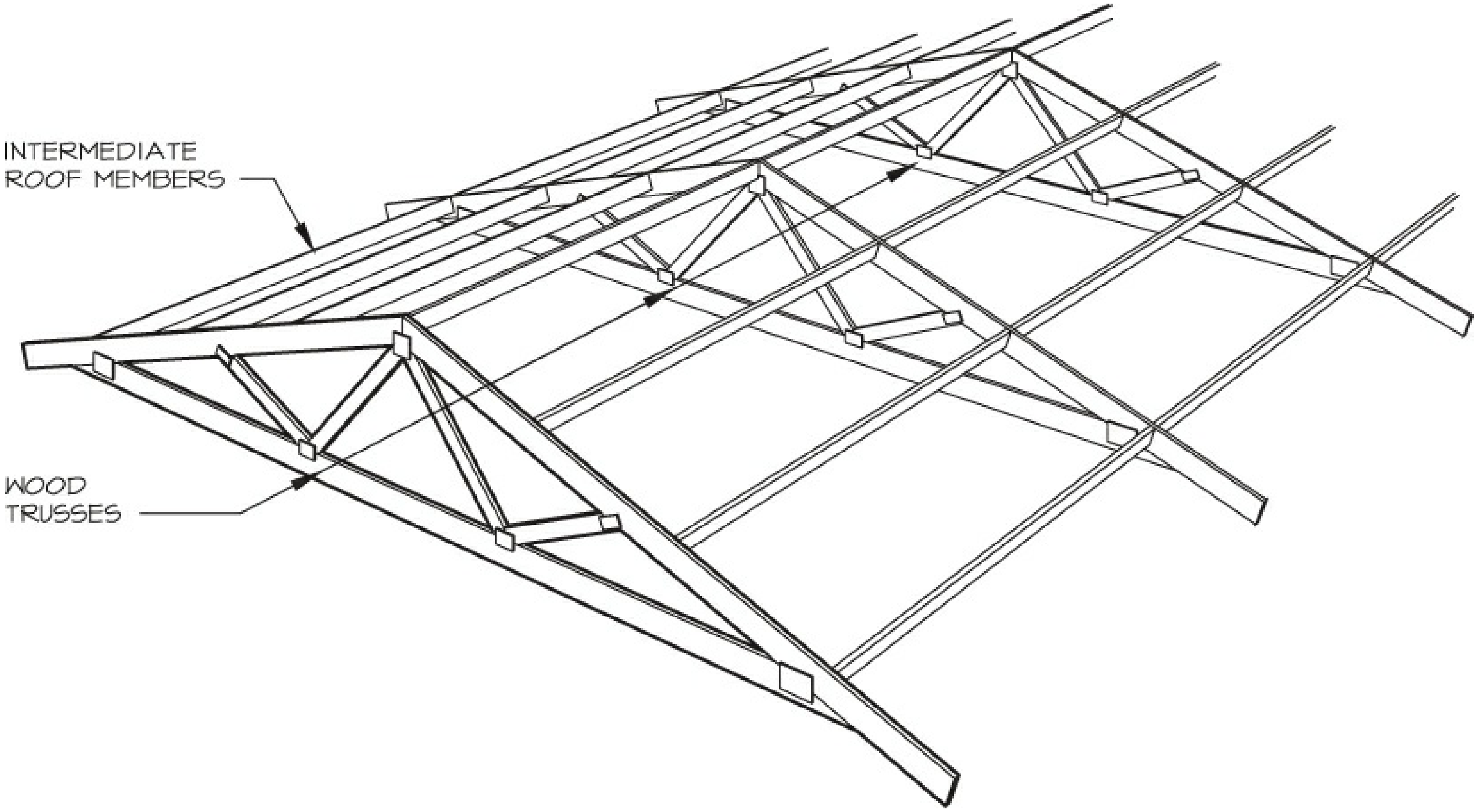


Figure 5.31 Wood truss roof system.

Panelized Wood Roof System

A panelized wood roof system is a construction method whereby plywood or OSB roof sheathing panels and intermediate supporting members are prefabricated in a manufacturing plant. Generally, the size of these panels is 4′ × 8′ because this is the standard dimension for plywood sheets. The thickness of the plywood sheathing is governed by the structural engineer's specifications. The supporting intermediate members of the plywood are generally 2 × 4 placed at 24″ center to center. Once the panels are fabricated, they are lifted and placed within the 4′ × 8′ module dimensions of the roof's main supporting members. The panels are attached to the main and intermediate supporting members with the metal framing connectors. The main supporting members may be glue…laminated (glulam) beams, and intermediate members have a minimum thickness of 4″. This roof framing system is generally used in the construction of industrial and manufacturing buildings. See Figure 5.32.

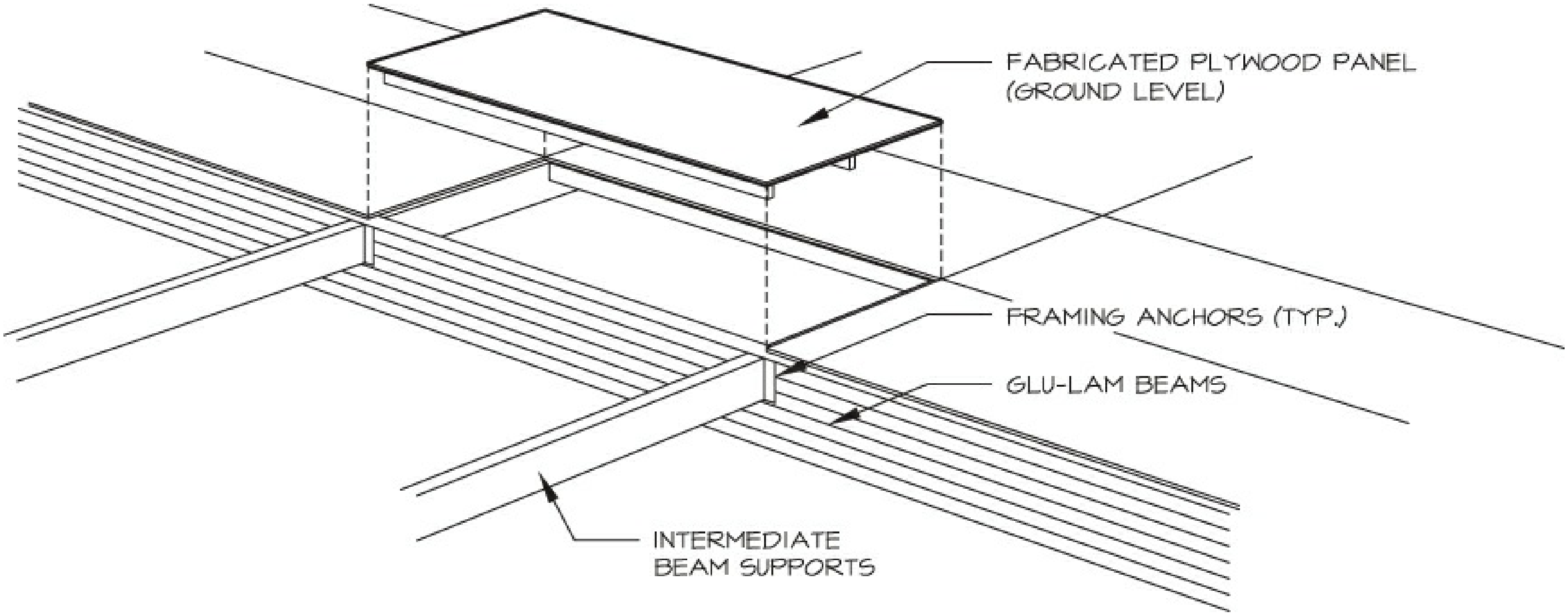


Figure 5.32 Panelized wood roof system.

Engineered Lumber Roof System

The use of engineered lumber members for roof rafters provides a straighter and stiffer frame, which is also more consistent in size and shape, for a wood roof system. See Figure 5.33. The structural capabilities of these members allow for the use of different types of roofing materials, and can handle snow…loading conditions. When engineered lumber is used, roof pitches may vary from a low pitch to a steep roof condition. The depth of these members may range from 5½″ to 16″, depending on the particular engineered lumber fabricator or manufacturer. See Figure 5.33.

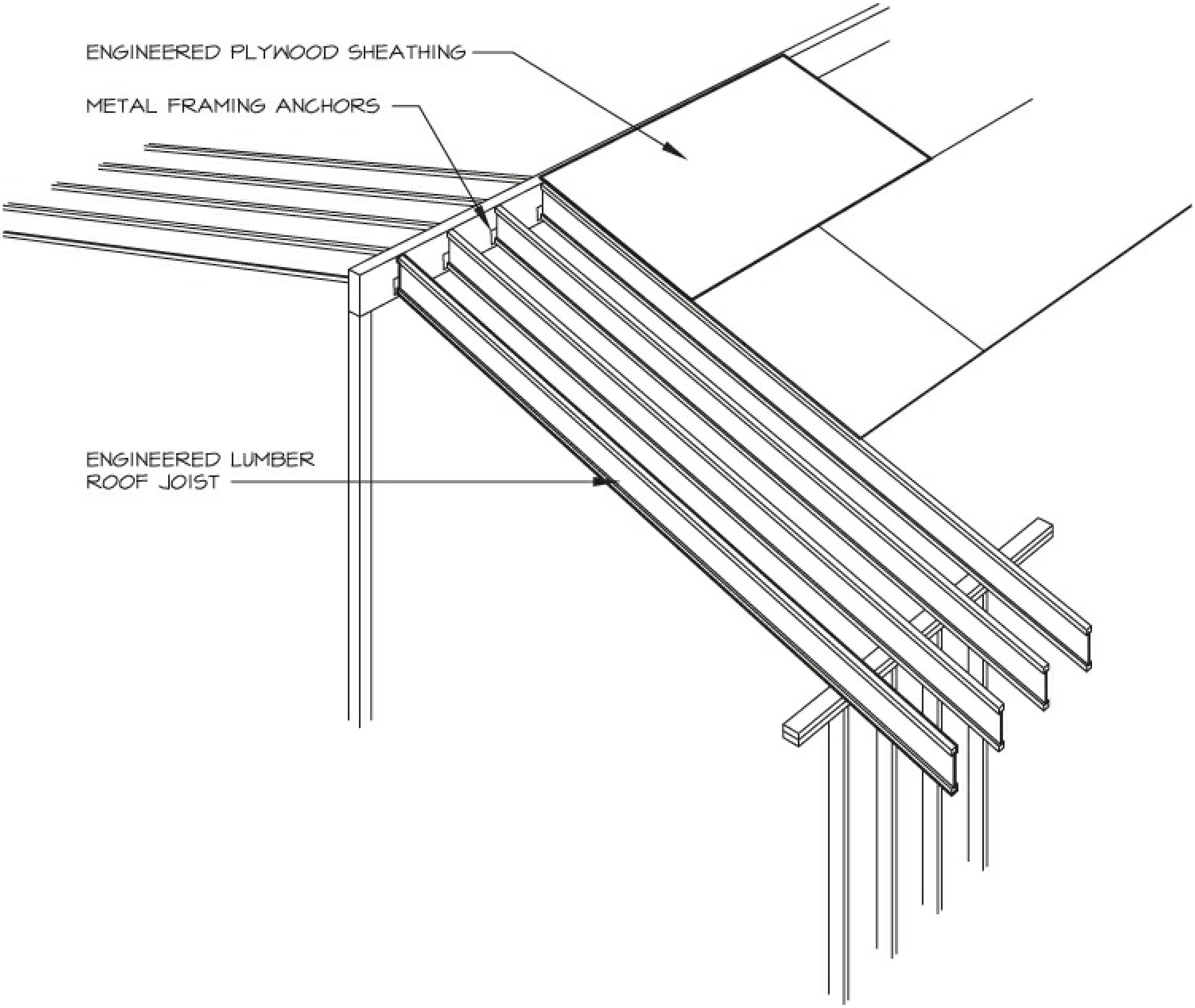


Figure 5.33 Engineered lumber roof system.

Wood That Does Not Burn

Recently, a product was introduced to the architectural world that is worth investigating. It uses the entire tree and produces a product somewhat like engineered lumber. However, there is one major difference. The lumber that is produced uses glass as one of the ingredients, resulting in lumber that will not burn. A close look at this product by doing an Internet search of the terms “wood won't burn” will lead you the web site of the manufacturer of this product.

CONCRETE

Concrete Material

Once concrete has been selected as the structural material for a building project, it is necessary to decide whether the concrete will be poured in place or precast concrete will

be used. If precast concrete units have been selected for construction of the exterior and interior walls and the roof system, it is of paramount importance to consult with the project's structural engineer. From the approved preliminary building design, the structural engineer will determine the thickness of the interior and exterior walls. The thickness of a wall will depend on whether it is a load‐bearing or non‐load‐bearing wall and whether it will have to resist wind, snow, or lateral loads. These determinations will allow the architect to lay out the exact wall thickness on the floor plan. See Figure 5.34. This initial drawing of the floor plan establishes the wall thickness for the load‐bearing and non‐load‐bearing precast concrete walls. The walls shown on matrix lines A, B, and D are non‐load‐bearing walls and have been determined to be 5″ thick. The wall thickness for the load‐bearing walls along matrix lines 1 through 9 are to be 7″ thick. The load‐bearing walls have been engineered to support 6″ precast concrete cored slab panels, which will span 21′. The use of a matrix system provides clarity for identifying the various precast concrete panel locations. See Figure 5.34.

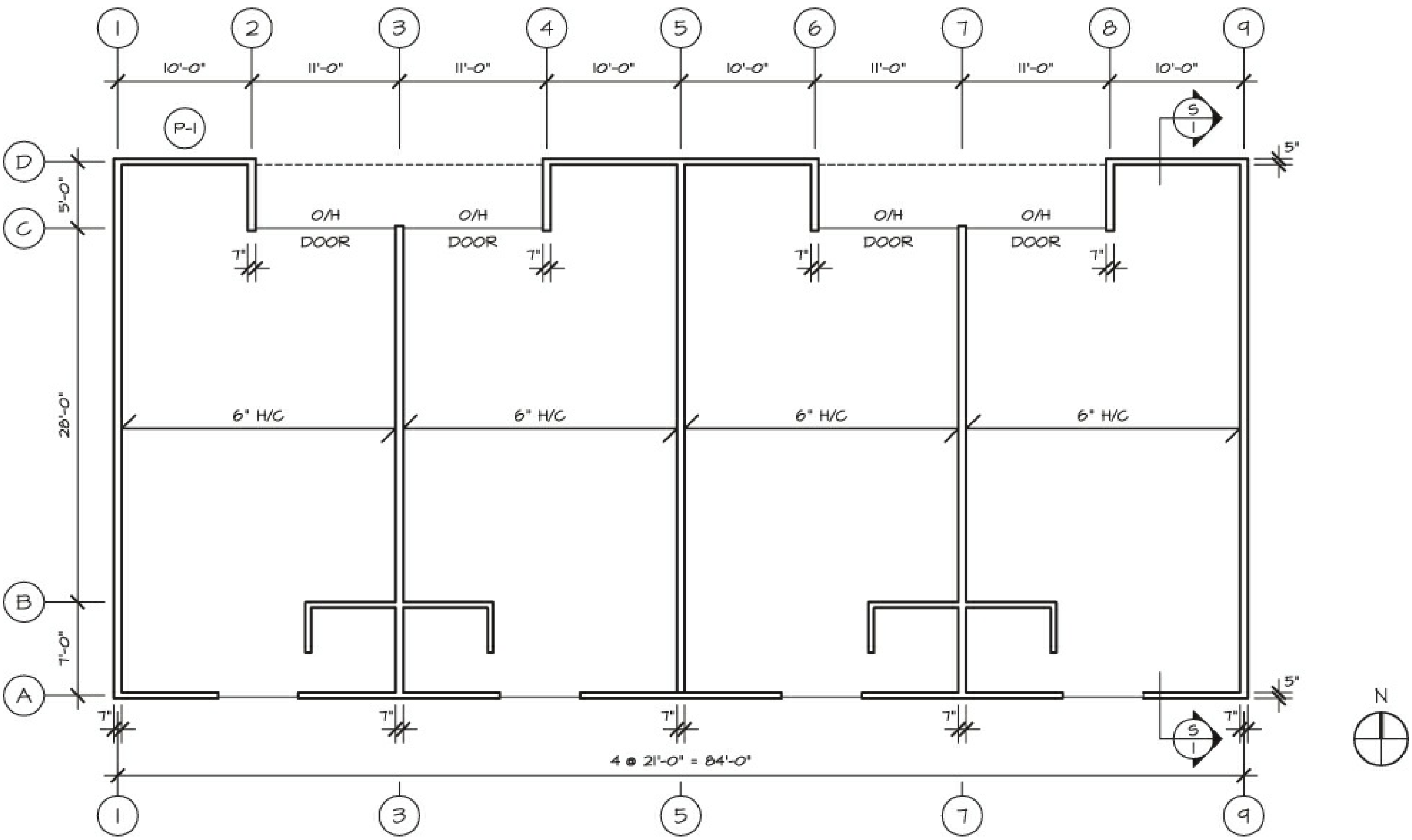


Figure 5.34 Plan layout—precast concrete walls.

The next step in developing the floor plan layout is to provide the building dimensions and the various wall thickness dimensions. Also noted at this time are the directional arrows for the spans of precast hollow‐core panels that will support the roof. Indicated on the span directional arrows are the thickness of the concrete cored slab panels, which is 6″, and the abbreviation HC, which means hollow core. A directional arrow is drawn between the matrix symbols 1 and 9 to further illustrate the bays that the hollow‐core

precast panels are spanning. On this arrow are noted four bays at 21′, with an overall length of 84′. At this stage, the basic floor plan layout shows the primary structural members.

Exterior Elevations

Because this is a light manufacturing building, it was decided to provide 14′…high ceilings. The ceiling heights thus dictate the wall heights. Figure 5.35 depicts the north elevation, and Figure 5.36 illustrates the west elevation. As shown, these exterior elevations illustrate the dimensioning of such items as the top of the parapet, the ceiling level height above the concrete floor, and the height of the steel overhead doors. These dimensions provide the necessary information for the sizes of the precast concrete wall panels, which will be manufactured and delivered to the building site. Also indicated on the north elevation are the precast sections that are to be finished in a textured scored concrete. See Figure 5.37.

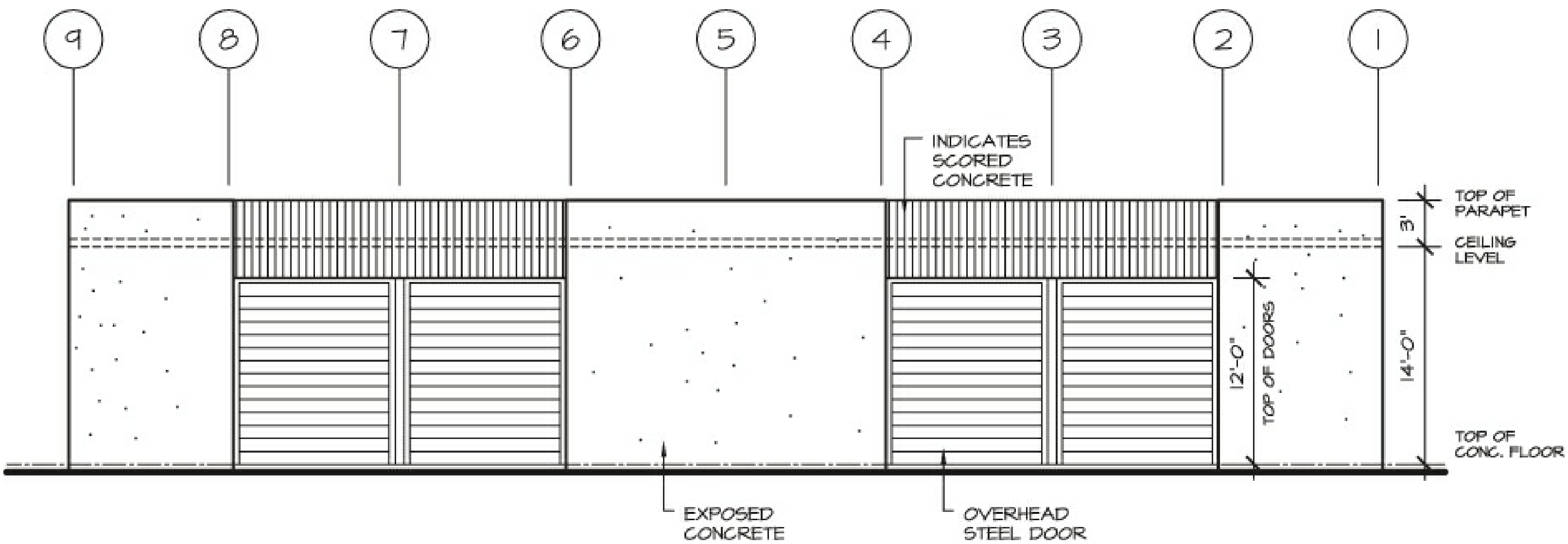


Figure 5.35 North elevation.

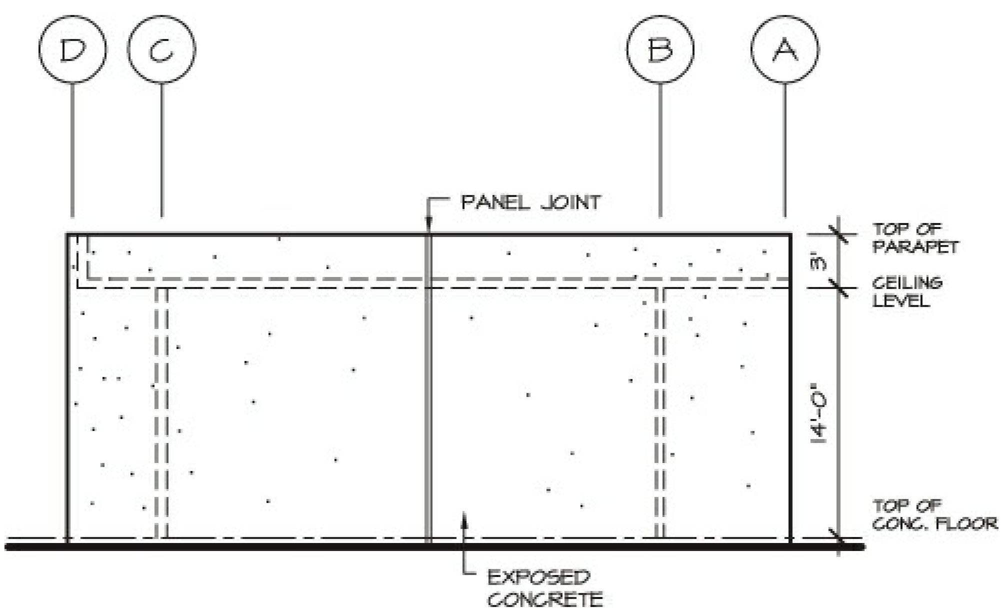


Figure 5.36 West elevation.

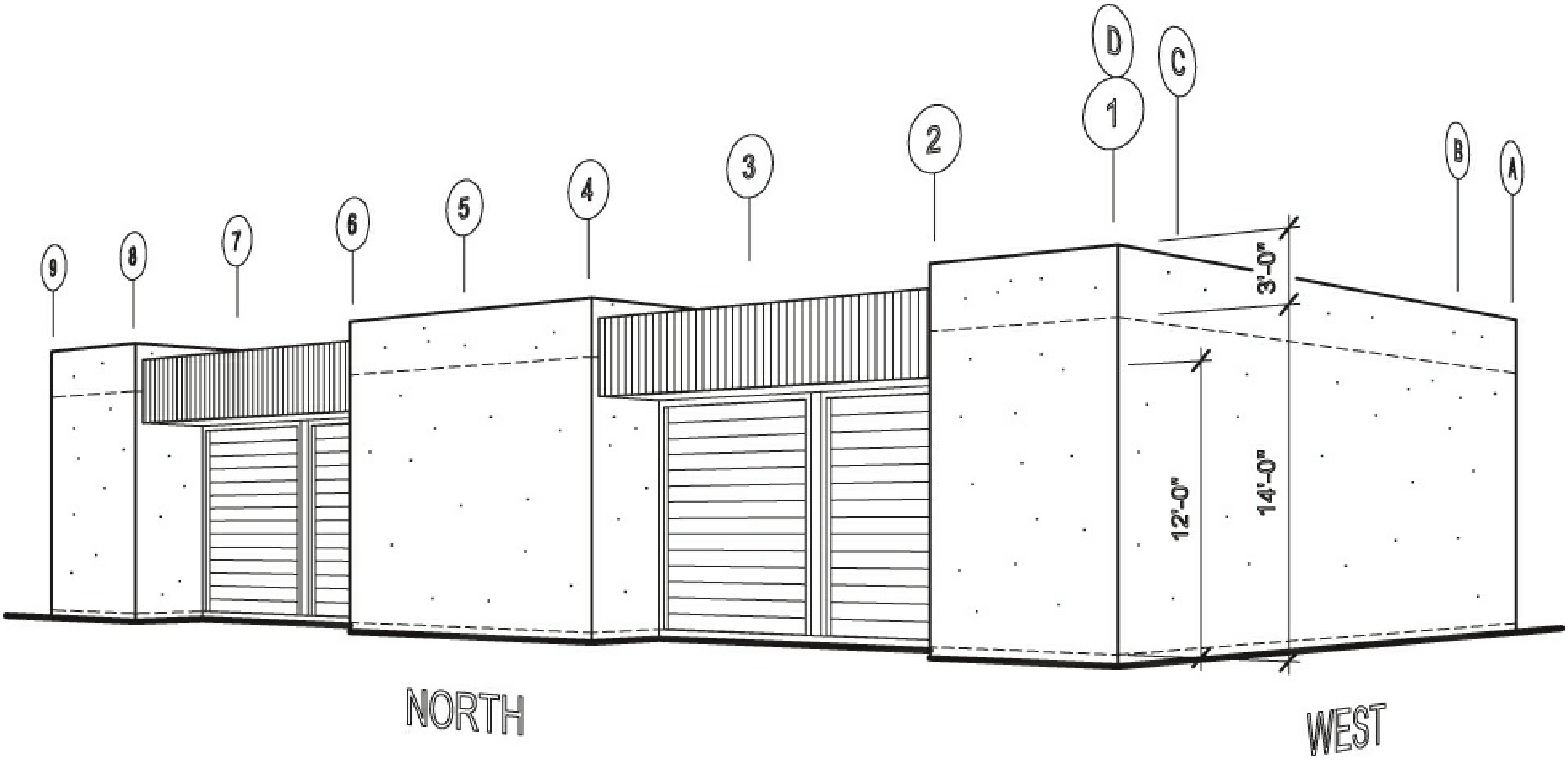


Figure 5.37 View of north/west elevations.

Building Sections

In conjunction with the necessary drawings for the building sections, it will be important to develop the precast panel drawings illustrating the wall dimensions and wall thickness for each specific panel. These panels should be identified with an elevation drawing and a panel identification number. See Figure 5.38. The precast panel to be placed between matrix numbers 1 and 2 from Figure 5.35 is defined as panel P…1. Panel identification may be shown on the floor plan, or a key plan may be provided.

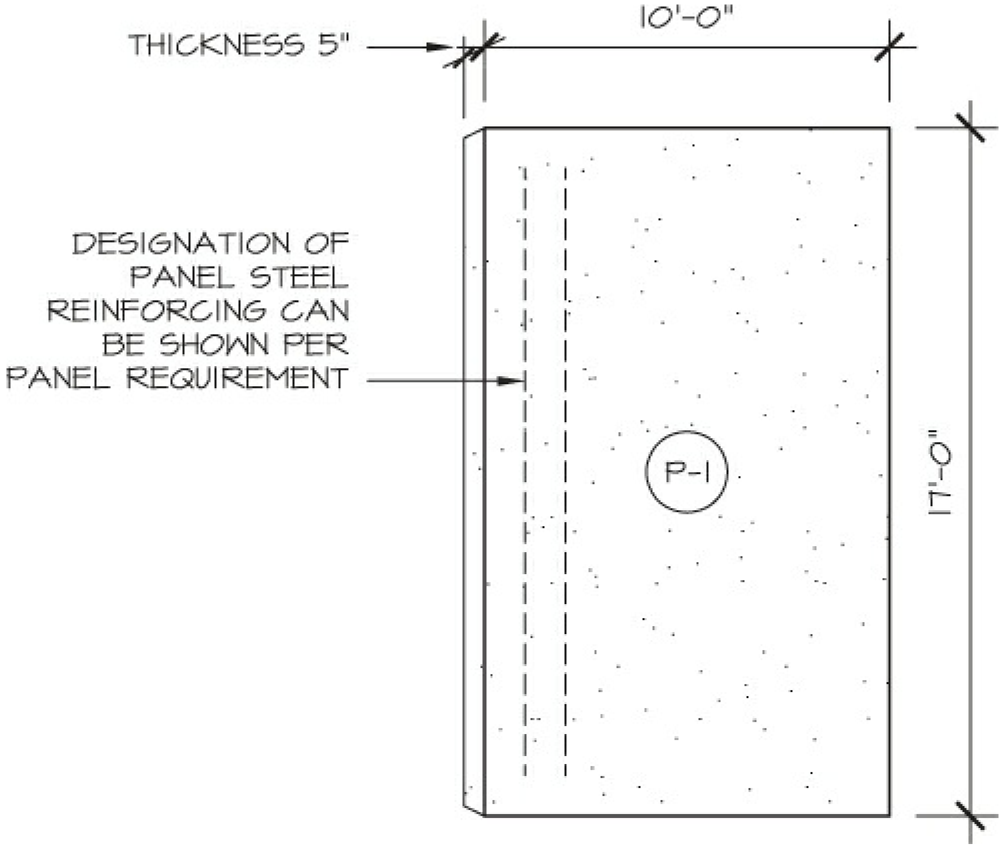


Figure 5.38 Precast concrete panel.

The number of building sections to be illustrated on a set of working drawings will be the number needed to clearly explain and show the various conditions that exist for a specific building. Figure 5.39 depicts a building section cut in the north…south direction as referenced on the floor plan. The figure illustrates the dimensional heights for the ceiling and parapet and identifies the direction of the precast concrete cored roof panels. At the east and west outside walls, a corbel or haunch, which is formed in the precast wall panel, will be necessary to support the precast cored panels at the end wall conditions. See Figure 5.40. Similar requirements and drawings will be necessary for a project using a poured…in…place concrete construction method. These requirements will pertain to wall height dimensions, wall thickness, steel reinforcing, and any type of architectural feature.

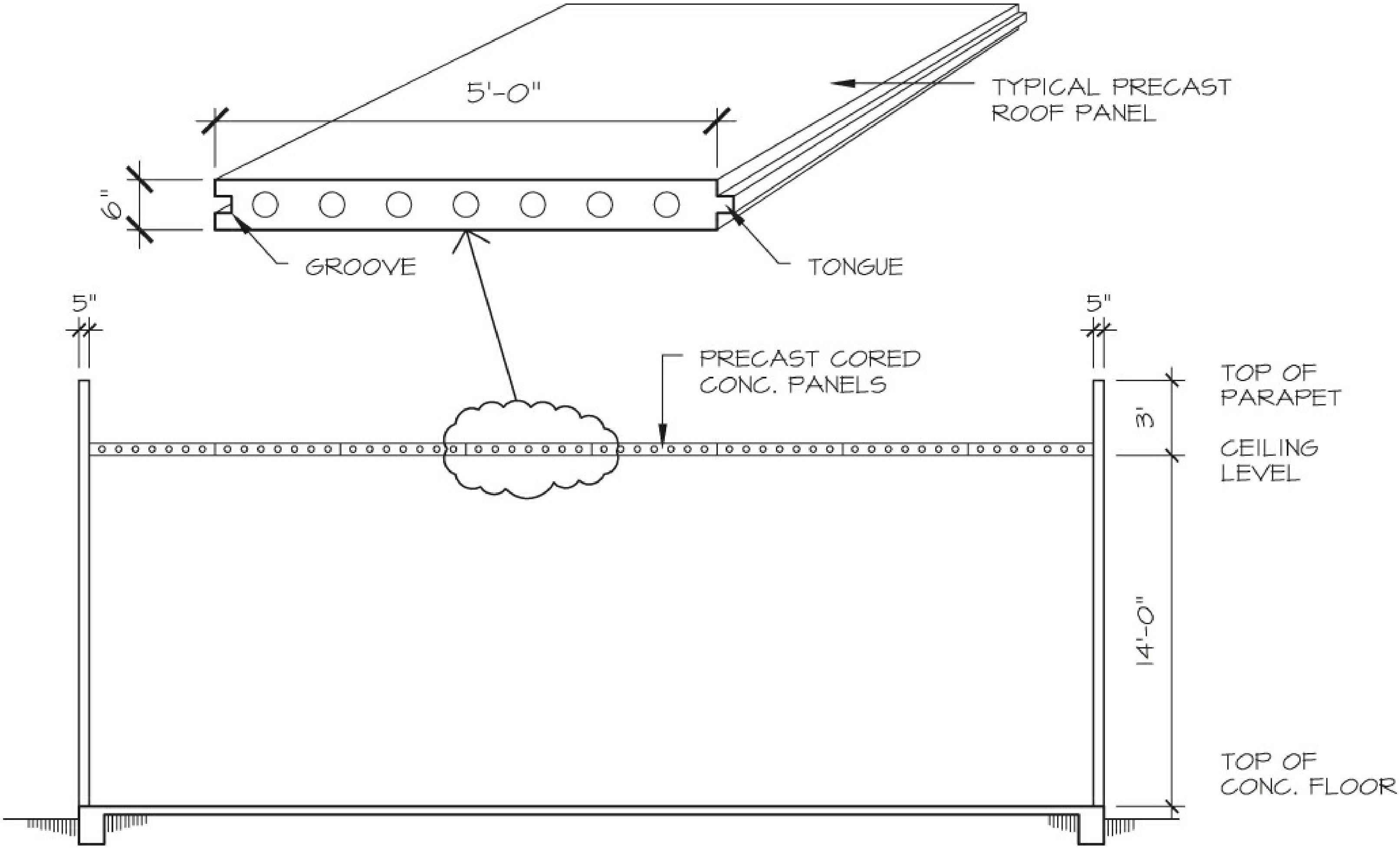


Figure 5.39 Building section on S…1.

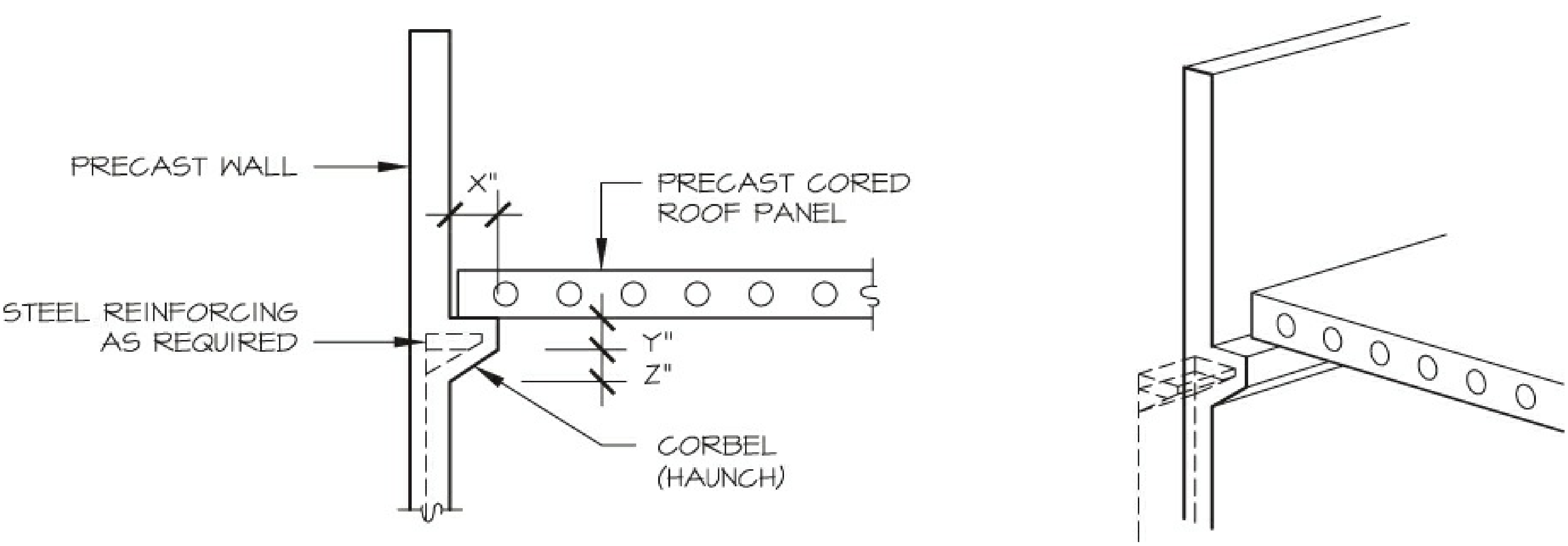


Figure 5.40 Wall corbel.

Concrete Floor System on Grade

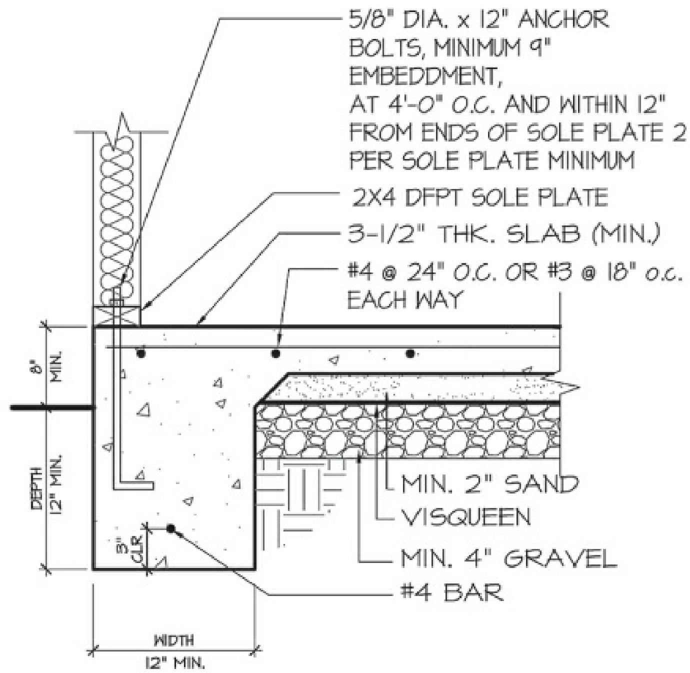
When concrete has been selected for a floor system on grade, factors influencing this selection may be the result of the following factors:

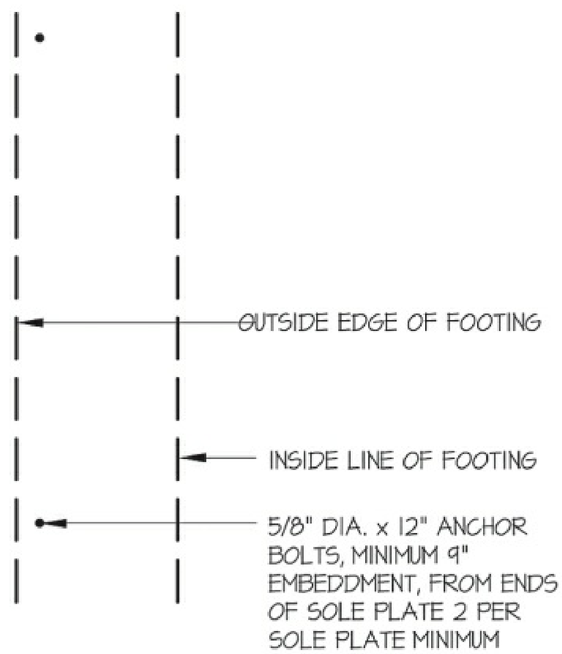
1. Acceptable soil conditions
2. Soundproofing requirements

3. Infestation conditions
4. Desire for a low building silhouette
5. Floor material finish
6. Basement condition

There are two main types of concrete floors and foundation systems. One type is the **monolithic system**, also referred to as the **one‗pour system**, in which the concrete floor and foundation are poured in one operation. The other system is referred to as the **two‗pour system**. In this system, the foundation walls and footings are poured first, followed by the concrete floor, which is poured separately. Although termed *two‗pour,* it could actually take several pours (three or more), depending on the size of the foundation system.

The construction methods for these two systems differ. In the one…pour system, the trenches become the forms for the foundation, as shown in Figure 5.41. For the two…pour system, formwork is required for the foundation wall. See Figure 5.42. A monolithic footing requires more concrete but less labor, as opposed to a two…pour footing, which also requires form lumber.


5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, AT 4'-0" O.C. AND WITHIN 12" FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM
2X4 DFPT SOLE PLATE
3-1/2" THK. SLAB (MIN.)
#4 @ 24" O.C. OR #3 @ 18" o.c. EACH WAY
8" MIN.
DEPTH 12" MIN.
3" CLR.
MIN. 2" SAND
VISQUEEN
MIN. 4" GRAVEL
#4 BAR
WIDTH 12" MIN.


OUTSIDE EDGE OF FOOTING
INSIDE LINE OF FOOTING
5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM

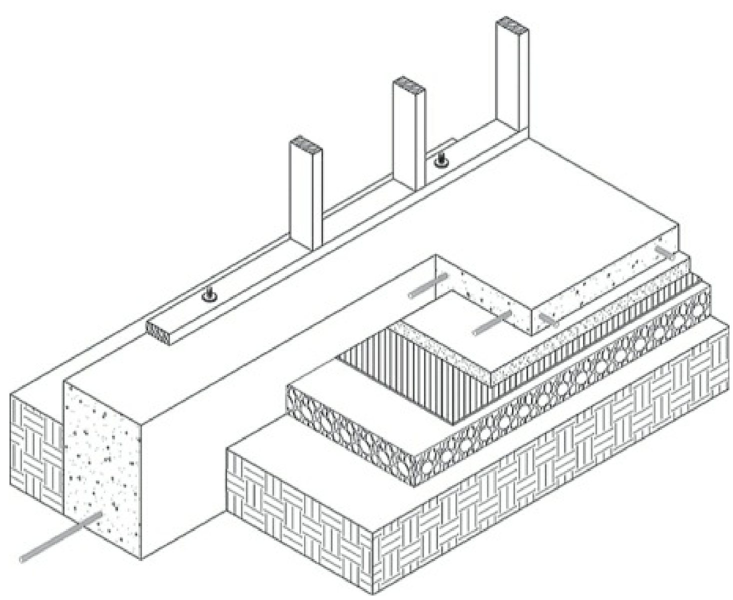
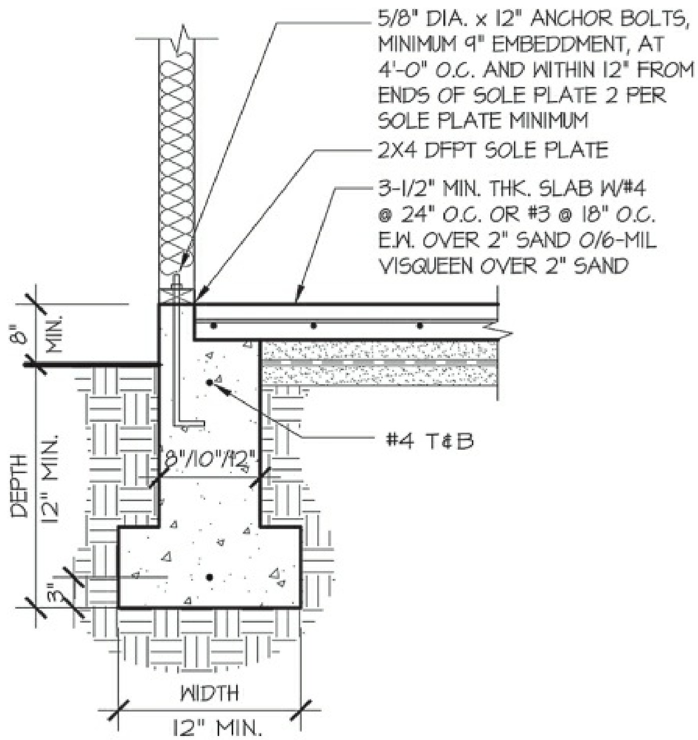
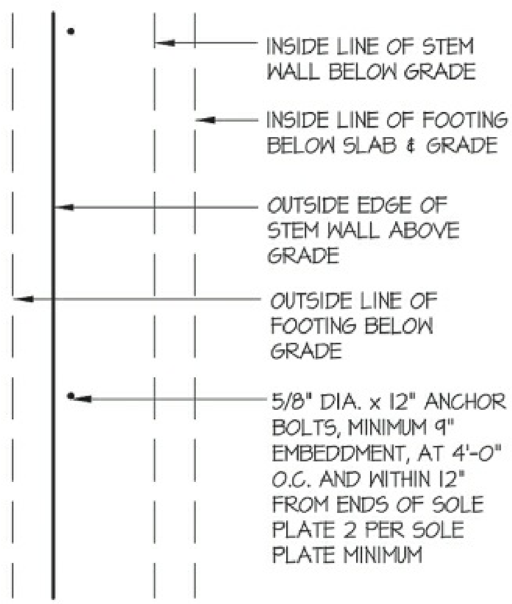


Figure 5.41 Detail of a one‐pour footing and floor.


5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, AT 4'-0" O.C. AND WITHIN 12" FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM
2X4 DFPT SOLE PLATE
3-1/2" MIN. THK. SLAB W/#4 @ 24" O.C. OR #3 @ 18" O.C. E.W. OVER 2" SAND O/6-MIL VISQUEEN OVER 2" SAND
8" MIN.
#4 T&B
8"/10"/12"
DEPTH 12" MIN.
3"
WIDTH 12" MIN.


INSIDE LINE OF STEM WALL BELOW GRADE
INSIDE LINE OF FOOTING BELOW SLAB & GRADE
OUTSIDE EDGE OF STEM WALL ABOVE GRADE
OUTSIDE LINE OF FOOTING BELOW GRADE
5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, AT 4'-0" O.C. AND WITHIN 12" FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM

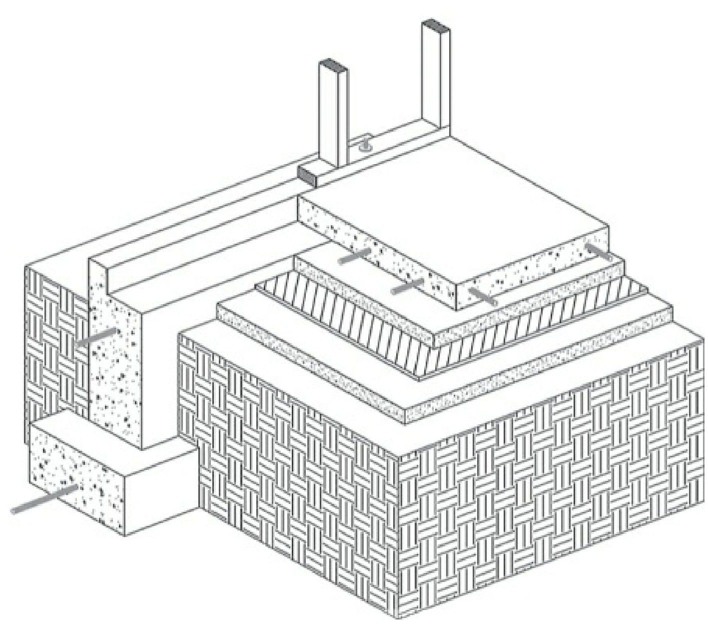


Figure 5.42 Detail of a two…pour footing and concrete floor.

Concrete Floor Steel Reinforcing

Just as a foundation must be strengthened with steel reinforcing, a concrete floor must be reinforced to prevent cracking. There are two primary methods of reinforcing concrete floor systems on a grade. One method is to use welded wire mesh, which is usually made of number 10 gauge wires spaced 6″ apart in each direction. Another method of reinforcing a concrete floor is to use deformed steel reinforcing bars with the spacing in each direction as recommended by a soils engineer. For example, the designation of the size of reinforcing bars and spacing could be number 4 bars at 18″ to 24″ center to center in each direction. The use of deformed steel bars is preferred for most soil conditions. See Figure 5.43.

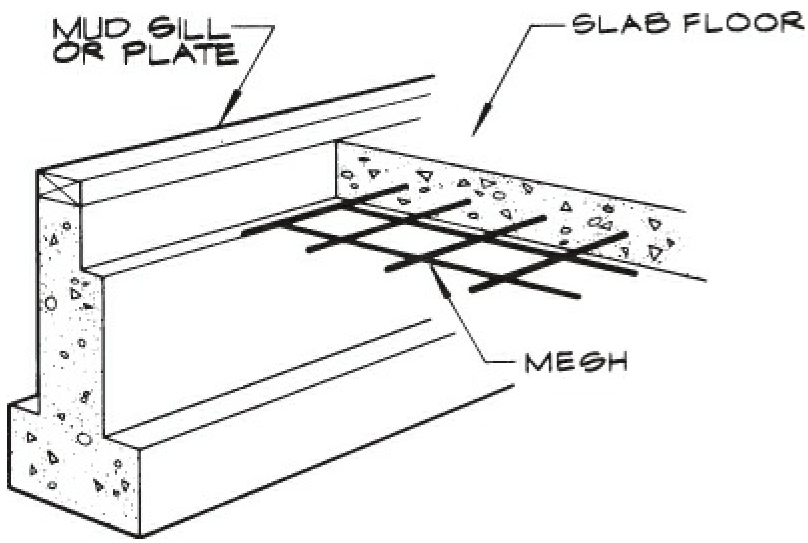
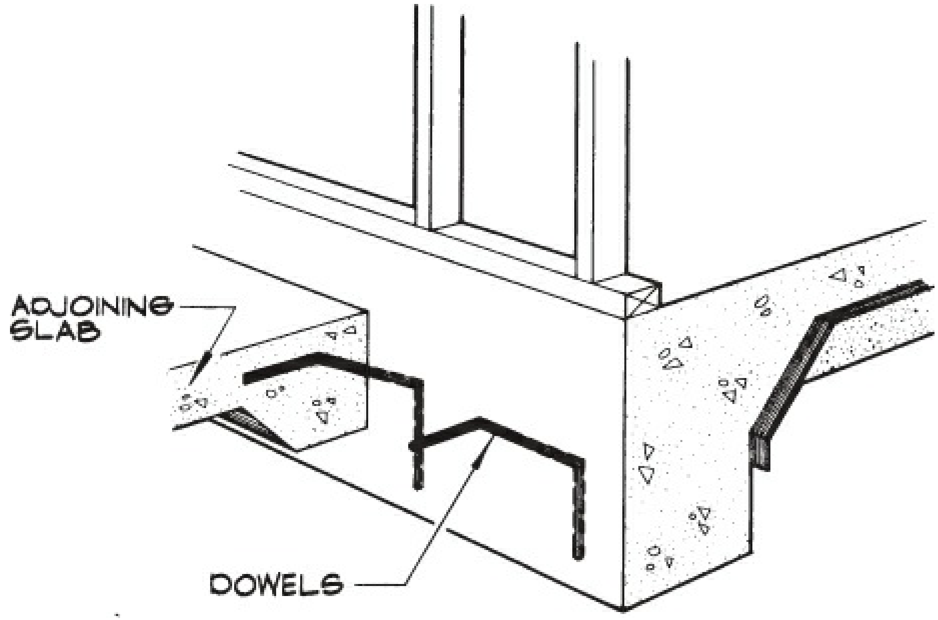


Figure 5.43 Concrete floor reinforcing.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

When confronted with having to hold two different pours of concrete together, such as a concrete porch slab and a main concrete floor, it is recommended that deformed steel dowels be used as the holding connection. These dowels may be number 3 bars or 3/8” diameter at 18″ to 24″ center to center. See Figure 5.44.



[Figure 5.44](#) Use of steel dowels to tie porch slab to concrete floor.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Concrete Floor Systems above Grade

There are various types of construction methods for concrete floor systems that are used in above‐grade and multilevel concrete floor construction. These concrete floors are erected with the use of various forming and steel reinforcing methods, with assemblies created on the job site in preparation for the concrete placement. One of these methods is referred to as a **two‐way flat slab**. The formwork is completely flat. The concrete slab is reinforced in such a way that the varying stresses are accommodated within the uniform thickness of the slab. The concrete slab thickness may vary from 6″ to 12″ in depth. The depth, as well as the steel reinforcing, is determined by the consulting structural engineer. See Figure 5.45.

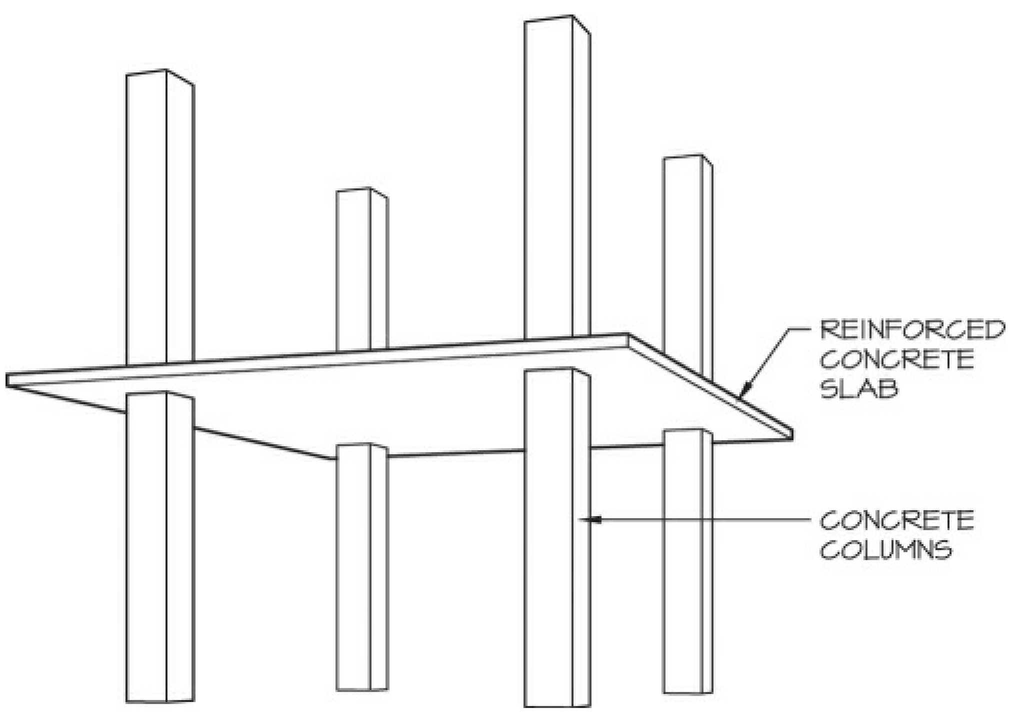


Figure 5.45 Flat slab floor system.

Another concrete floor system used in many buildings is a two‐way solid slab system. In this system, a solid flat slab is supported by a grid of concrete beams running in both directions over supporting concrete columns. In general, a flat slab concrete floor system is very economical because of the simplicity of the formwork. Steel reinforcing bars will be incorporated in projects with recommendations from the structural engineer. These systems impose limitations on the length of spans for the flat slab. See Figure 5.46.

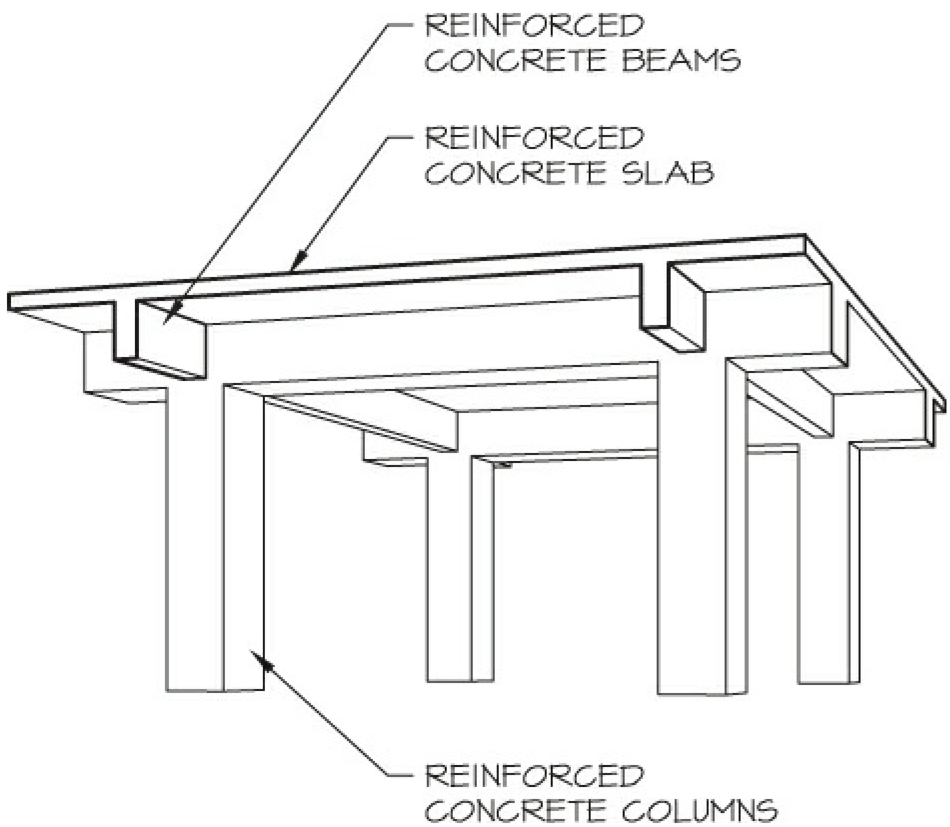


Figure 5.46 Two‐way solid slab system.

Precast Prestressed Concrete Systems

The use of precast prestressed concrete structural components for floor systems in buildings has many advantages over the use of concrete poured in place at the job site. Precast prestressed concrete components such as slabs, beams, girders, columns, and wall panels are manufactured at a precasting plant and delivered to the building site for erection. Precasting plants offer excellent quality control of materials and workmanship and minimize waste in concrete and steel.

An example of a precast prestressed slab floor system utilizing a precast double‐tee‐shaped floor slab with support beam is illustrated in Figure 5.47. The thickness of the slab and the amount of steel reinforcing are dictated by the length of the span and the weight that will be loaded onto the floor. The solutions are dictated by the structural engineer's findings. Note in Figure 5.47 that the precast double tees are supported on steel‐reinforced concrete walls.

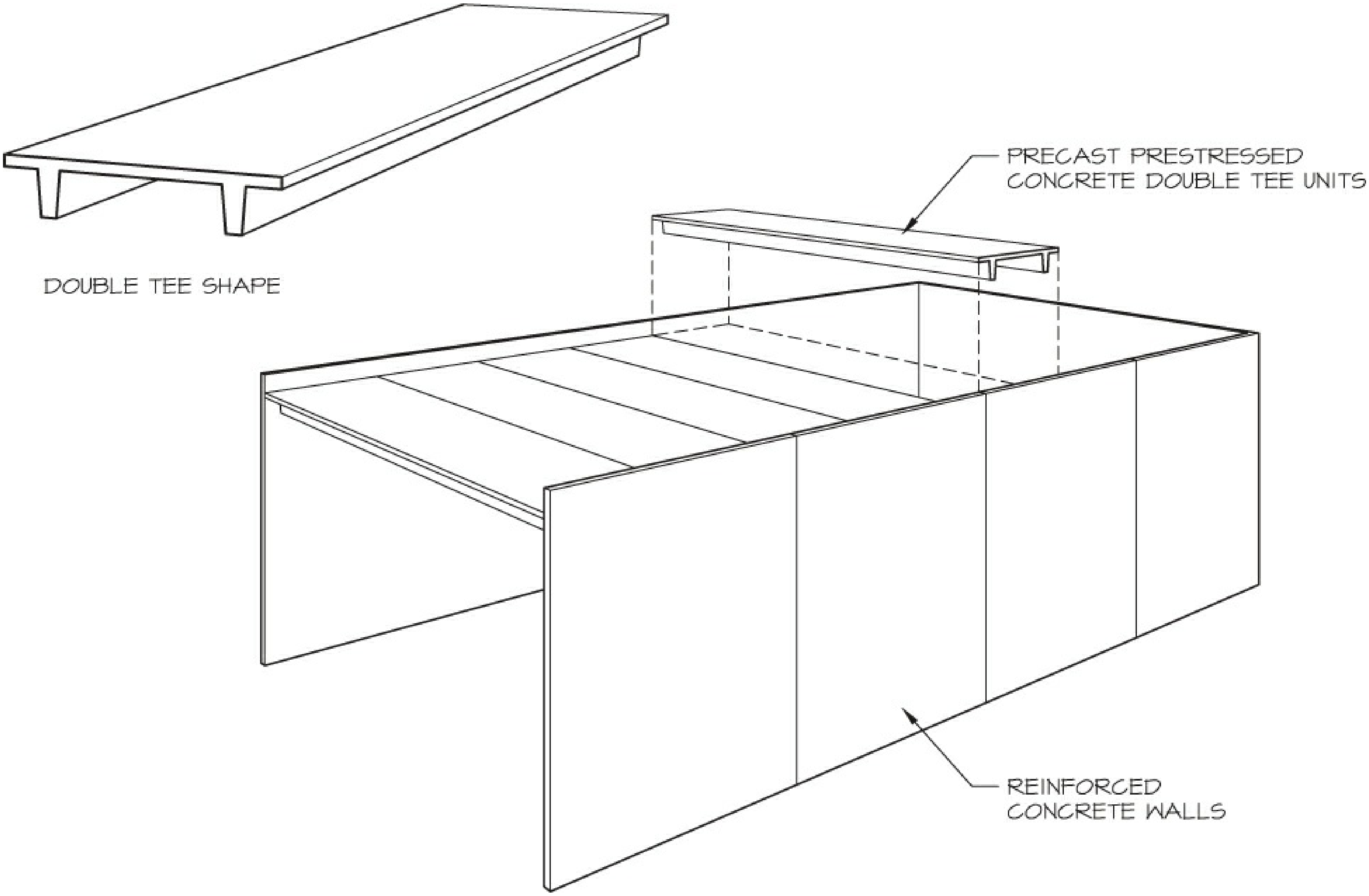


Figure 5.47 Precast prestressed slab system.

Figure 5.48 shows a solid flat slab reinforced unit that will be lifted into place and supported by concrete beams and concrete columns. This type of precast slab is used for short span conditions.

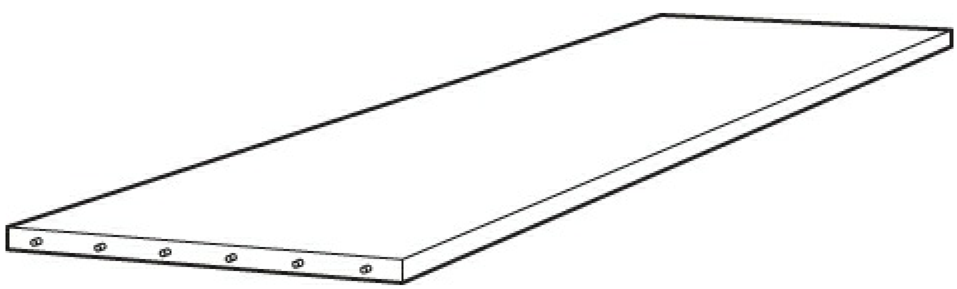


Figure 5.48 Precast prestressed solid flat slab.

Figure 5.49 illustrates a precast prestressed hollow…core slab panel. The hollow cores further reduce the dead weight of the concrete panel. These hollow…core slab panels are best suited for intermediate spans and can be supported by concrete beams and concrete columns.

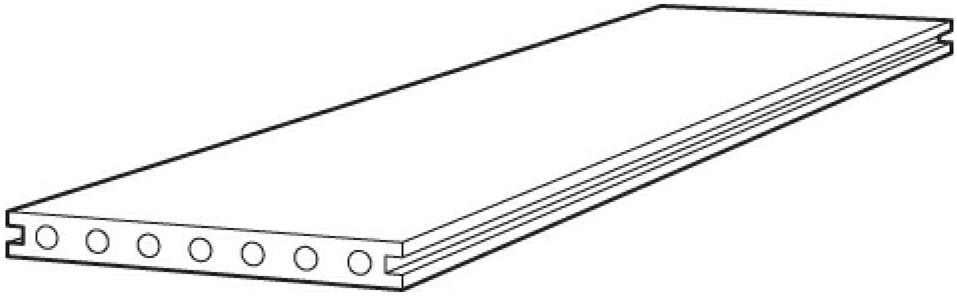


Figure 5.49 Precast prestressed hollow‐core slab.

Figure 5.50 depicts a precast prestressed concrete single tee. This type of precast unit and the double‐tee unit are desirable for longer spans. The single tees are used less frequently than the double tees, because the single tee requires a temporary support to relieve tipping. The examples shown are the most commonly used precast prestressed concrete elements for floor systems; they are also used for concrete roof systems.

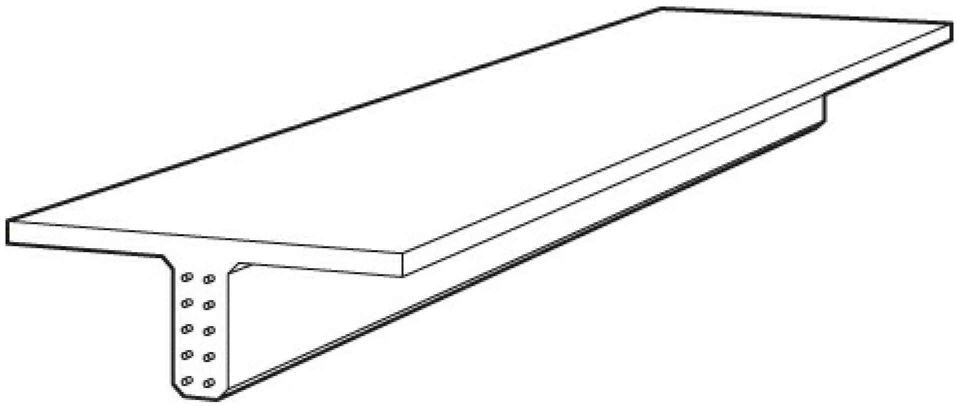


Figure 5.50 Precast prestressed concrete single tee.

Concrete Wall Systems

A commonly used concrete wall system that is poured in place is called a **concrete retaining wall**. As with most poured‐in‐place concrete, wood forms are constructed on both sides of the wall and tied together to resist the weight and force of the poured concrete. Steel reinforcing bars are required and are attached to the wood forms before the concrete is poured. See Figure 5.51.

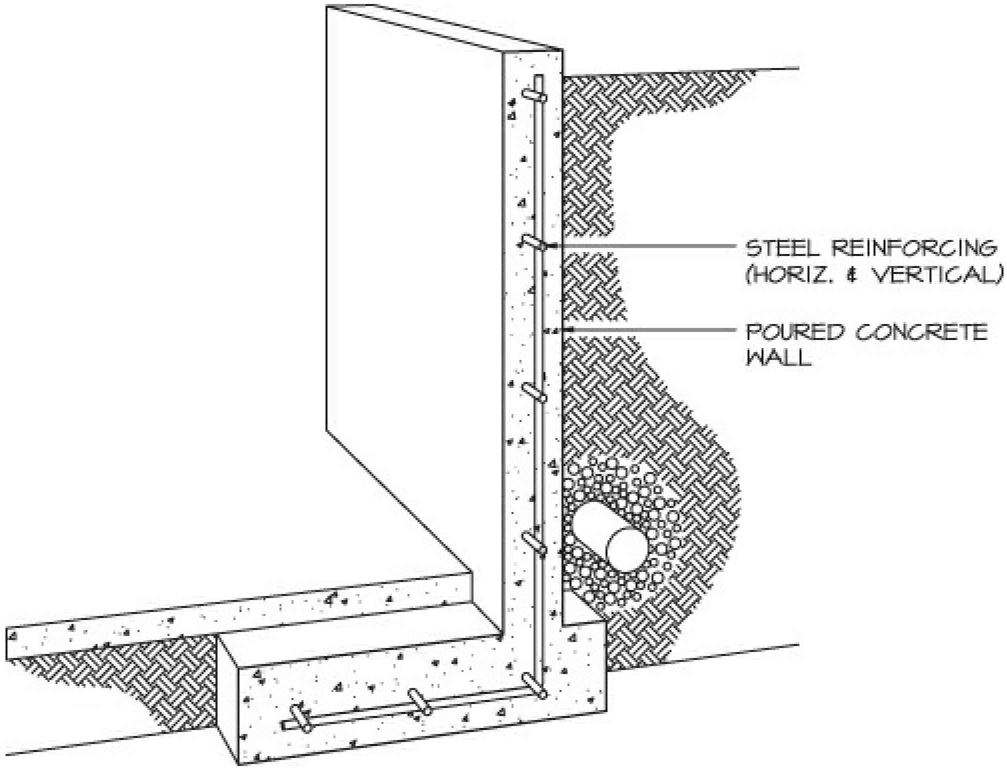


Figure 5.51 Poured…in…place concrete retaining wall.

Concrete walls are also utilized in basements for below…ground conditions, and can be manufactured as described earlier with wood forms. Metal forms are used in a manner similar to the wood forms but are best for a more repetitive dimensional system. If the measurements are uniform, the use of modular metal forms is a more efficient system of forming. These forms can be rented and are intended for frequent use. In either case, any basement wall must be waterproofed.

Concrete Tilt…Up Wall System

Tilt…up wall panels are used to support roof and floor loads and serve as shear walls to resist movement due to earthquakes and high wind conditions. See Figure 5.52.

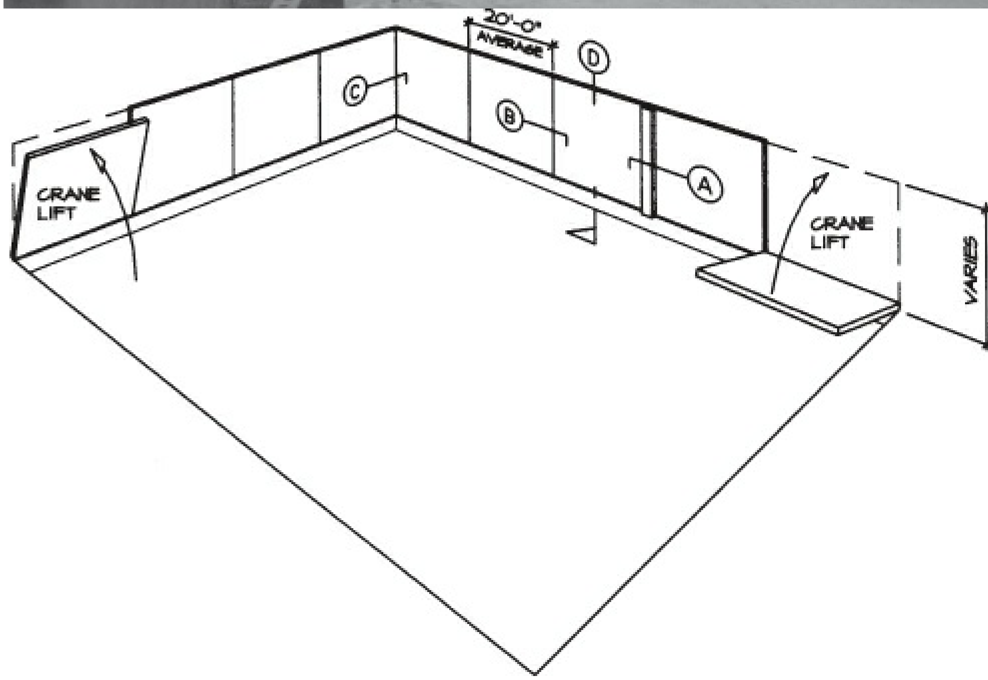


Figure 5.52 Tilt…up wall diagram.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Tilt…up wall construction is a precast construction method in which the wall panels are cast on the job site. In most cases, the concrete floor of the building serves as the casting platform for the wall panels. The panels may be of high…strength concrete and relatively thin. Tilt…up construction is especially suitable for commercial and industrial structures.

Generally, fabrication of a tilt…up wall is accomplished with the use of wood forms, reinforcing steel, and a bond…breaker liquid suitable to release the precast panel from the casting platform. After the concrete meets the curing specifications, the panels are lifted into place by a mobile truck crane. See Figures 5.53 and 5.54.

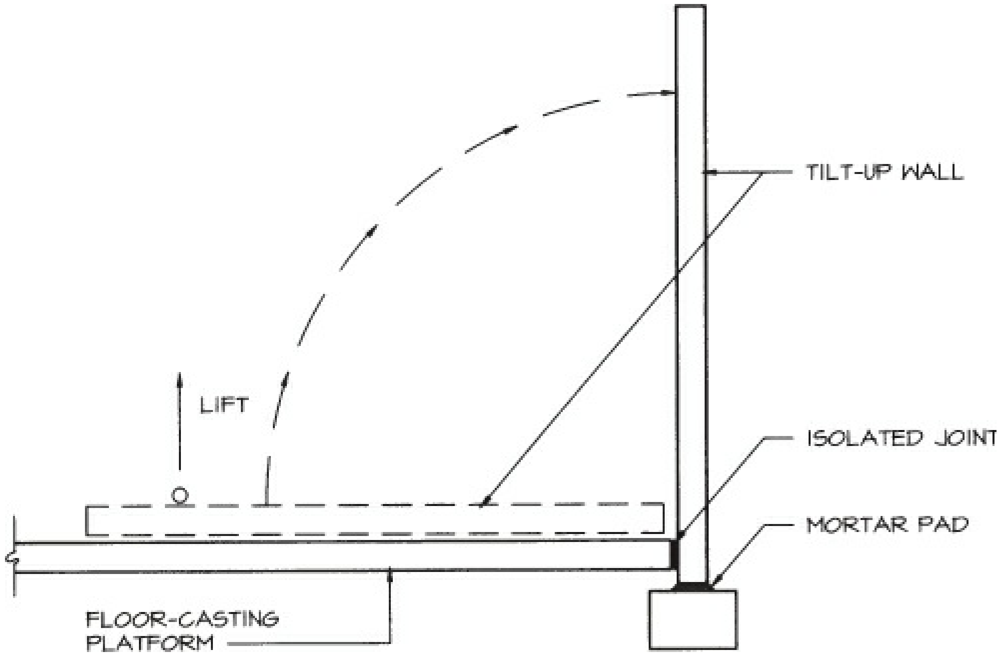


Figure 5.53 Tilt…up wall installation.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

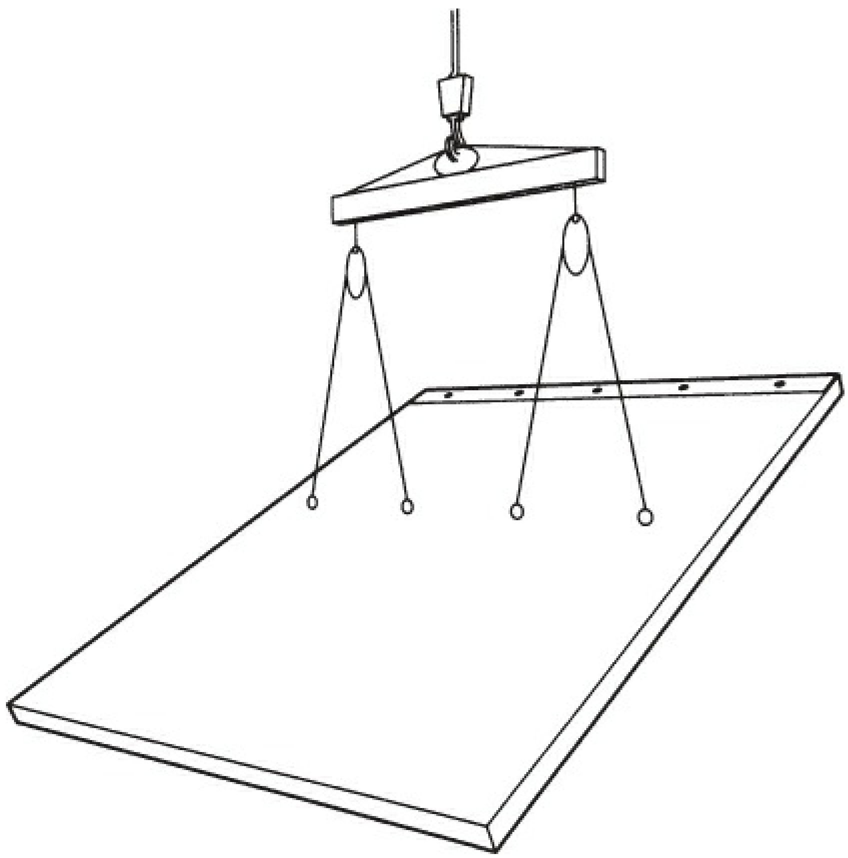
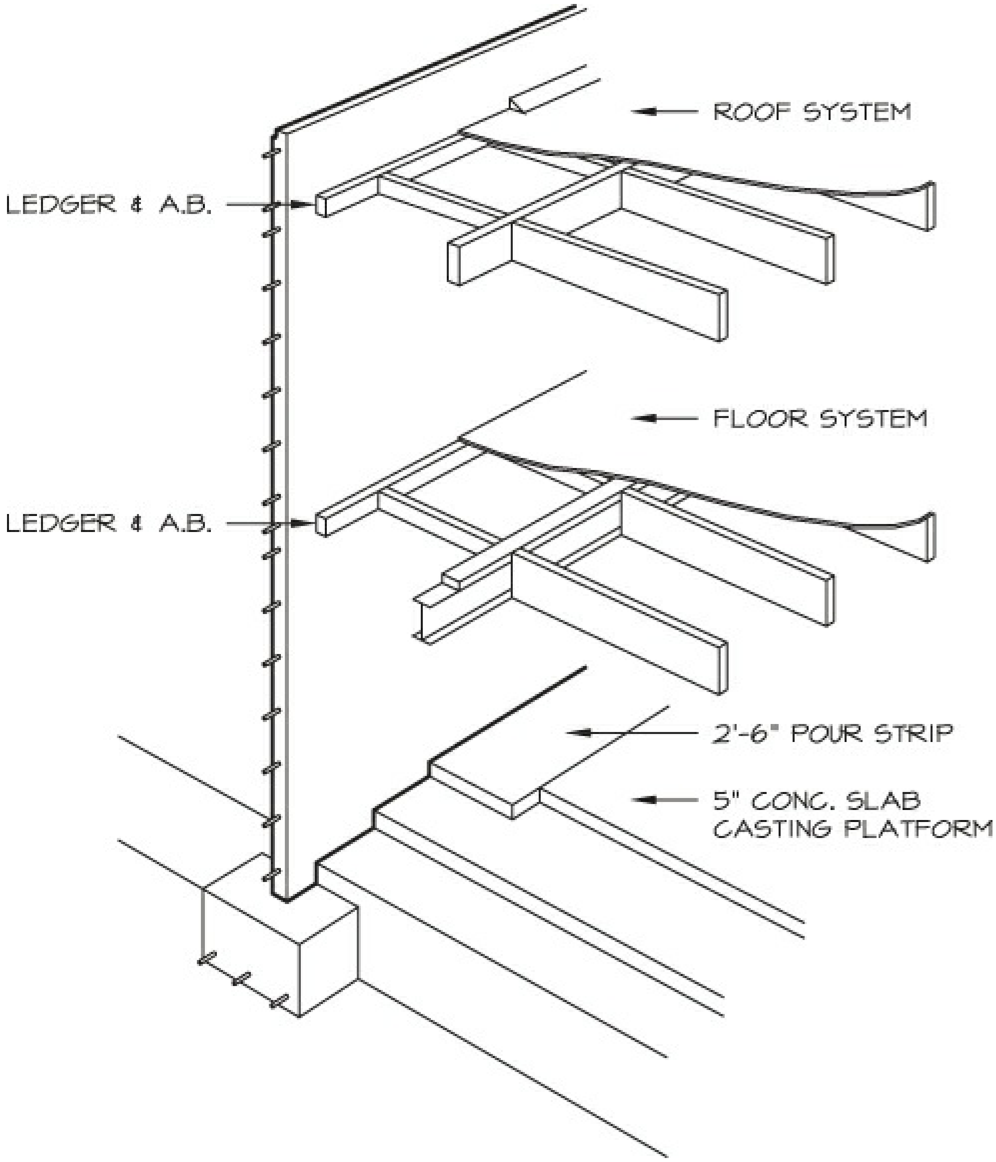


Figure 5.54 Tilt…up wall section.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

A detailed wall section for a two…story concrete tilt…up wall is illustrated in Figure 5.55. Note that a concrete pour strip is used to connect the wall and the casting slab after the tilt…up wall panel is erected.



[Figure 5.55](#) Concrete tilt…up wall.

Precast Concrete Wall System

A highly successful construction method for concrete walls is the use of precast concrete bearing and non…bearing walls. These walls are manufactured at a casting plant and delivered to the building site for erection. The walls may be cast with various openings in them, such as for doors and windows. The wall sizes and shapes vary, based on the designs of the architect and the structural engineer. Figure 5.56 depicts a precast concrete wall arrangement with the use of a precast concrete hollow…core floor system. Note that when wall openings are required, they may be incorporated into the internal and external planning. The connections for precast concrete elements, such as for walls, are dictated by the consulting structural engineer's detail. A wall…to…floor connection (section A) is shown in Figure 5.57. This detail does not show the steel reinforcing and grouting required to connect the walls to the floor system to maintain the structural integrity of the building. There are various methods of meeting these structural requirements.

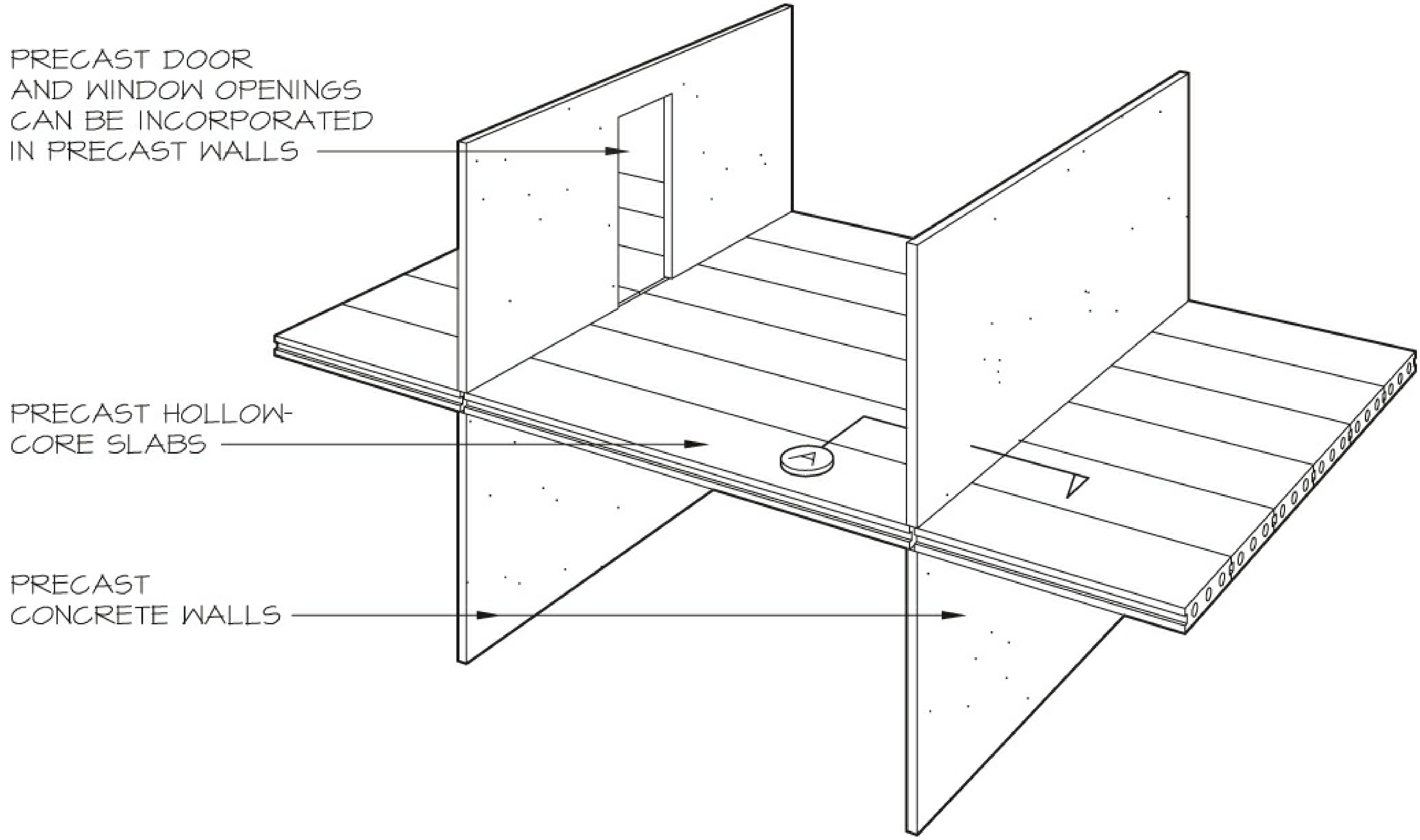


Figure 5.56 Precast concrete bearing walls.

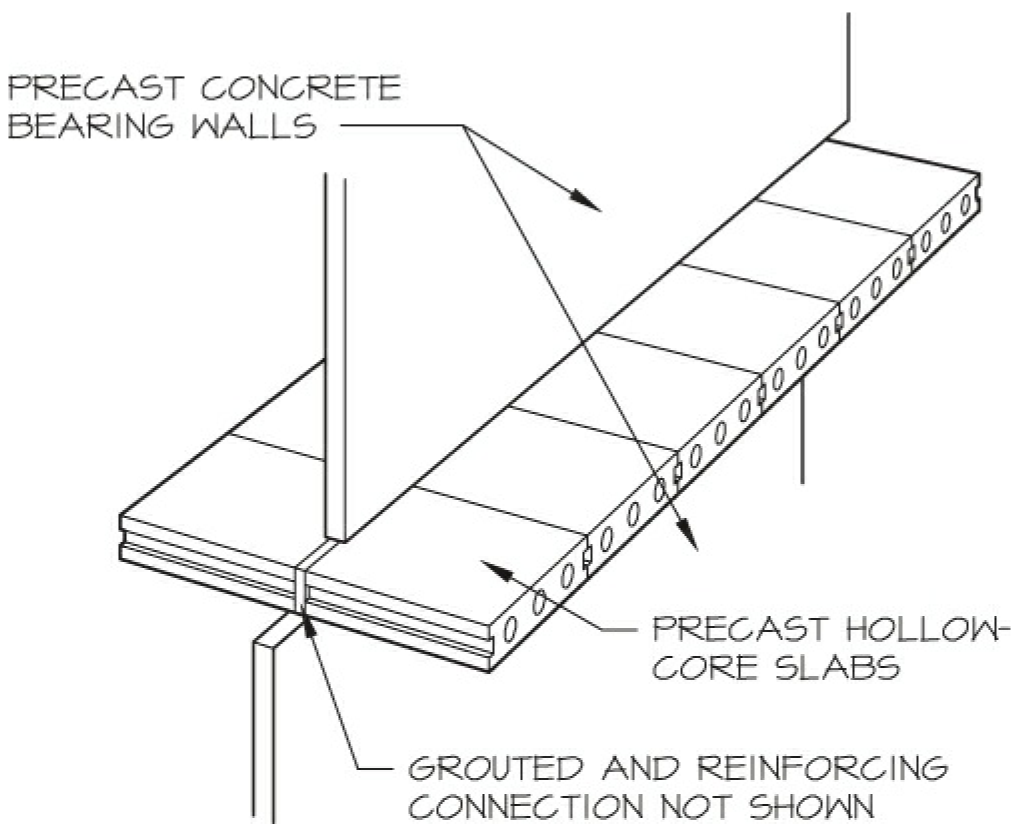


Figure 5.57 Precast walls and hollow…core slab.

Precast Concrete Roof System

The precast concrete elements used for a structural roof system are similar to those used for precast concrete floor systems. This system is depicted in Figure 5.58, where precast hollow…core planks are supported and incorporated with the use of precast concrete bearing walls. Note that the haunch used to support the hollow…core planks is part of the precast wall unit. Roofing insulation and the finished roofing application are applied directly over the hollow…core planking.

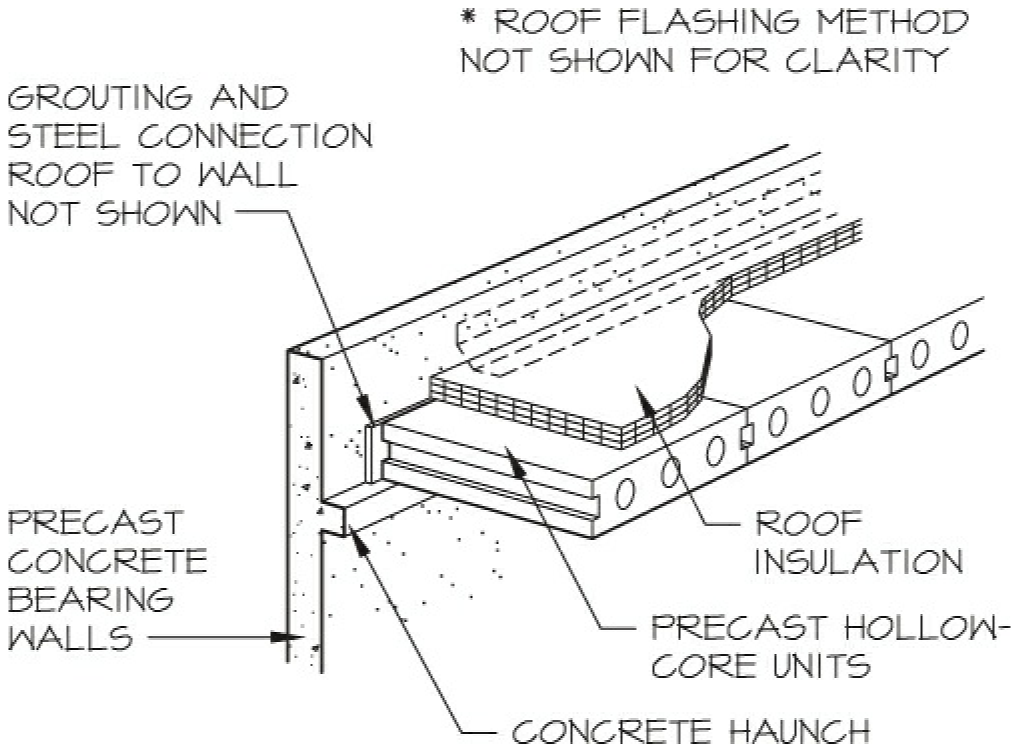


Figure 5.58 Precast concrete roof system.

STEEL SYSTEM

Steel

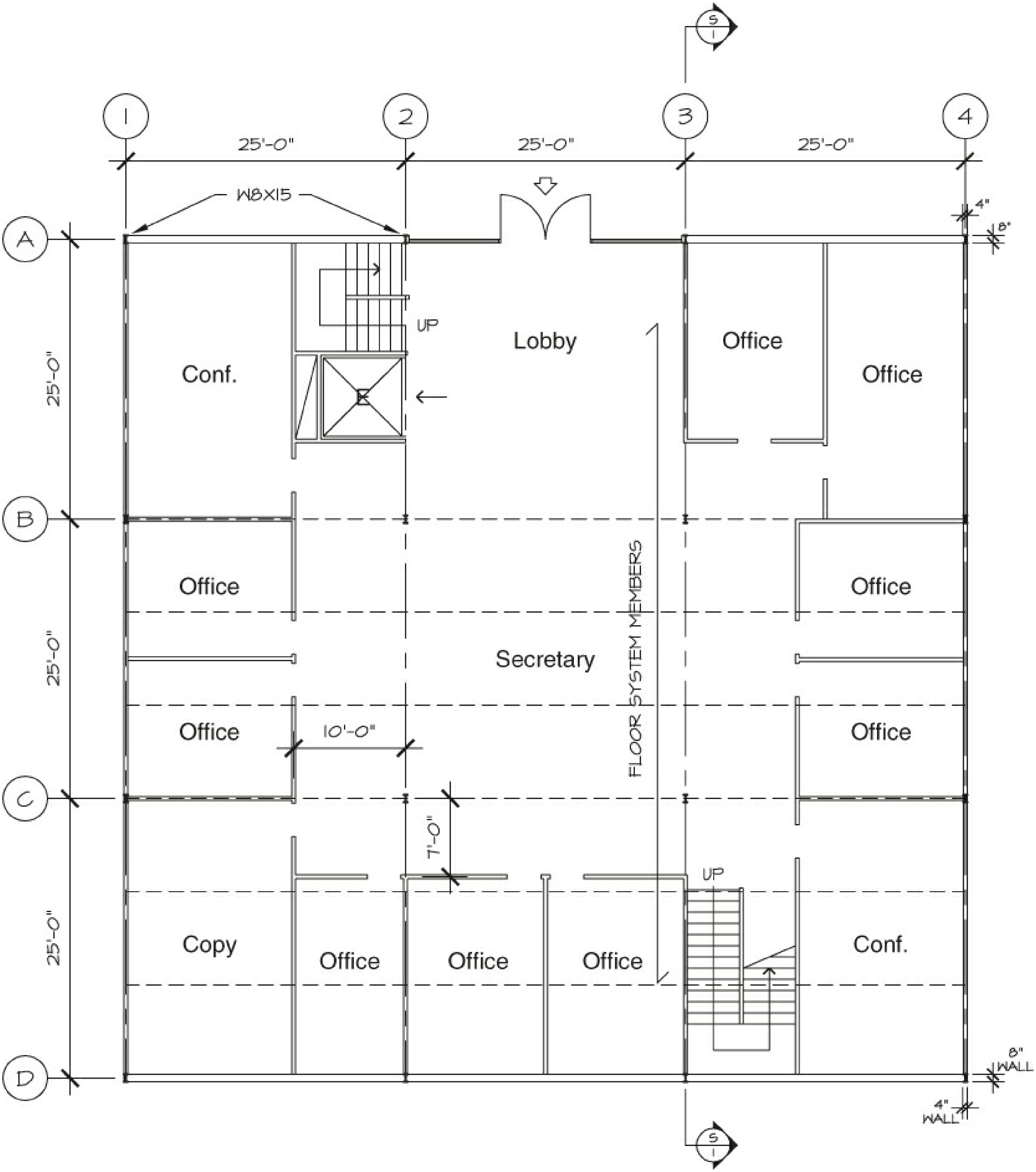
When selecting steel as a construction material for a building project, it is necessary to decide whether the steel components are to be structural steel members or light steel framing members. The use of structural steel members, such as “W” shapes, “S” shapes, tubes, or channels, will probably dictate the use of a matrix identification system. For a light steel framing system, the approach will be similar to that used for a wood stud framing system.

If an architectural firm has been commissioned to design and prepare working drawings for an office building incorporating structural steel members, then the game plan is to establish a matrix identification system. A matrix system will identify the column and beam locations as well as spread concrete footings and concrete piers. Before formulating a floor plan layout with the steel column locations, it is necessary to consult with the project's structural engineer for his or her recommended span lengths between the supporting steel columns. With the structural engineer's preliminary recommendations, the architects may proceed with the preliminary studies, incorporating the client's

requirements and all the other design considerations necessary in designing a building.

Floor Plan

When creating a floor plan for a building using structural steel members, it is desirable to incorporate continuity and simplicity in the column and beam spacing. This allows for standardization of column and beam sizing while maintaining simplicity in the steel fabrication process. Figure 5.59 depicts a ground‐level floor plan that uses a matrix system to identify the column and beam locations. To enclose the steel columns in the finished north or south walls, it will be necessary to have a wall 8″ or more thick. The columns along the matrix lines A and D are a minimum of 8″ in thickness. Their call‐out size is W8 × 15. W describes the wide flange shape; 8 is the depth measured in inches; 15 represents the weight in pounds per linear foot. The east and west walls will be dictated by the flange width of the steel columns along matrix lines 1 and 4. These flanges are 4″ wide.



[Figure 5.59](#) Ground…level floor plan.

The interior wall partition layout may be dimensioned from the various matrix line identifications. An example is shown on the ground…floor plan where the office partition walls are dimensioned from the column identified at matrix lines 2 and C.

Second…Level Floor Plan

In the second…level floor plan, columns and beams will align directly over the ground…floor steel members. However, the column and beam sizes will be different because they are not supporting as much weight as the ground…floor members. The steel columns on the second…floor level will be W6 × 12 members. The finished wall thickness, on the north and south walls, will thus have to be a minimum of 6″ to enclose the columns along matrix lines A and D. See Figure 5.60. The finished wall thickness along matrix lines 1 and 4 will have to be a minimum of 4″ because the flange width of the W6 × 12 steel column is 4″. When dimensioning the wall thickness for the enclosure of steel columns, it is recommended that the properties of the steel members be verified by referring to the *Manual of Steel Construction*.

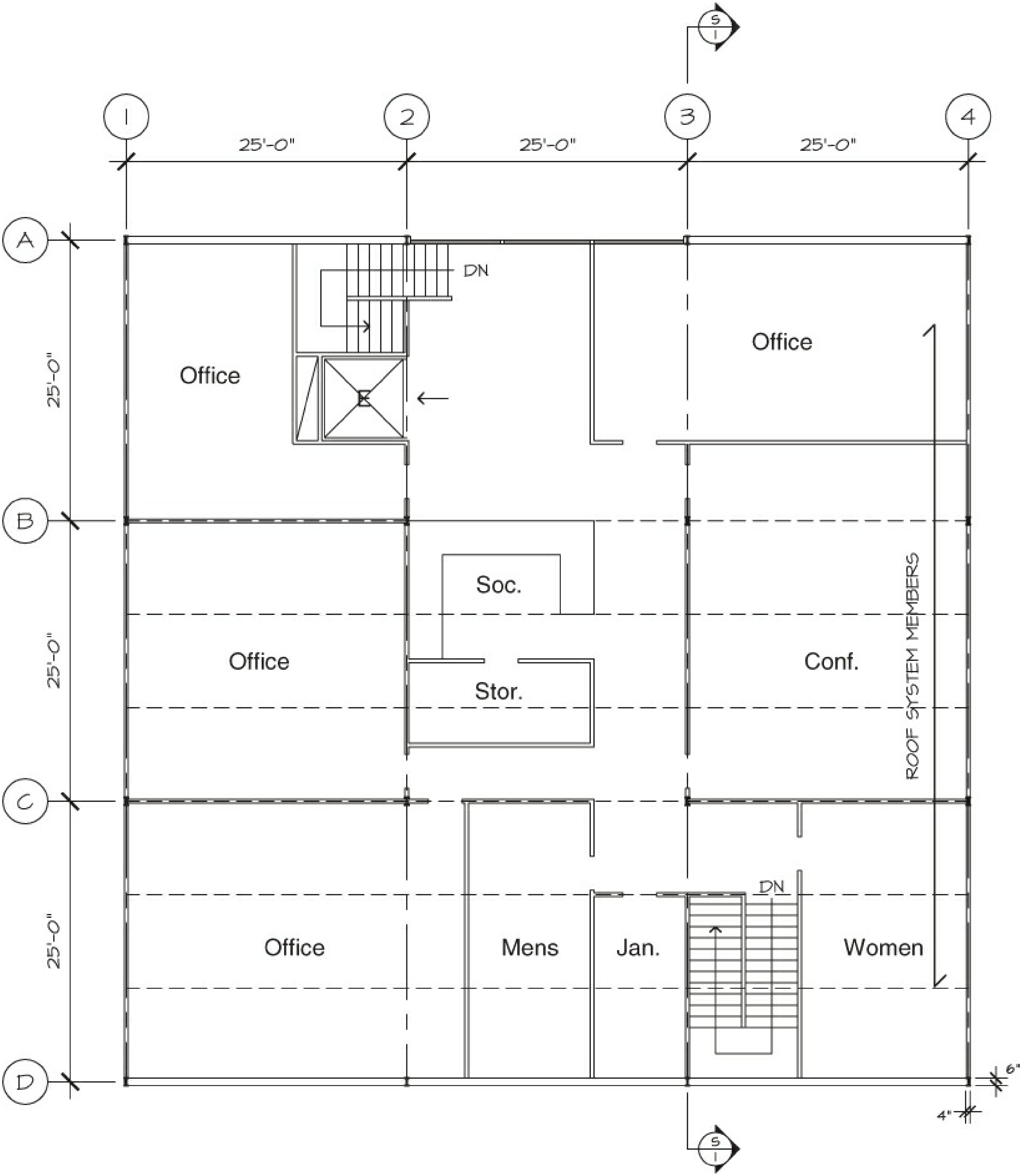


Figure 5.60 Second‐level floor plan.

Exterior Elevations

The process in developing preliminary exterior elevations is to coordinate the basic

requirements established by the structural and mechanical engineers. For example, the structural engineer may establish the unsupported heights for selected steel columns, and the mechanical engineer may provide a recommended dimensional clearance for the mechanical ducts. The plenum area is the allocated space between the top of the finished ceiling and the bottom of the floor and roof system members. This space is used for heating and cooling ducts and various plumbing lines. These dimensional requirements are needed for the layout of the preliminary exterior elevations relative to their building heights. See Figure 5.61.

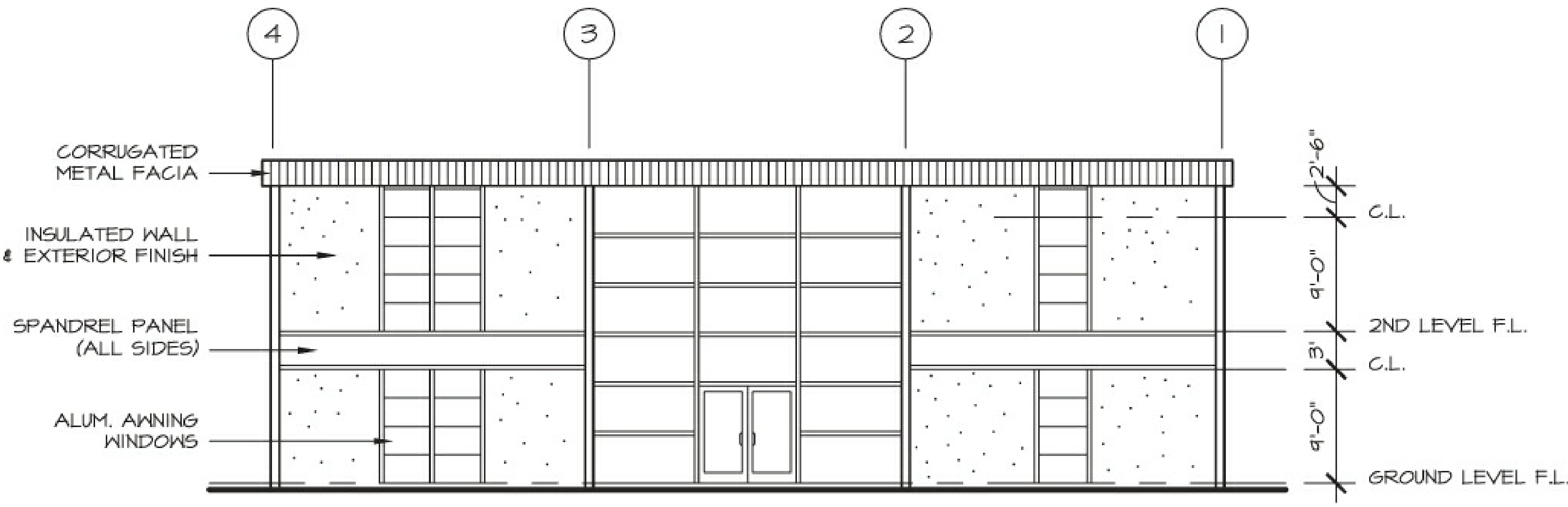


Figure 5.61 North elevation.

Building Sections

The initial layout dimensionally illustrates the recommended floor…to…finished…ceiling height, while also showing the recommended dimensional space for the plenum area. Preliminary engineering calculations provide the approximate steel column and beam sizes necessary for development of the building sections.

Figure 5.62 is taken along matrix line 3, which is in the north…south direction looking eastward. Refer to the ground…level floor plan in Figure 5.59 for the building section designation symbol.

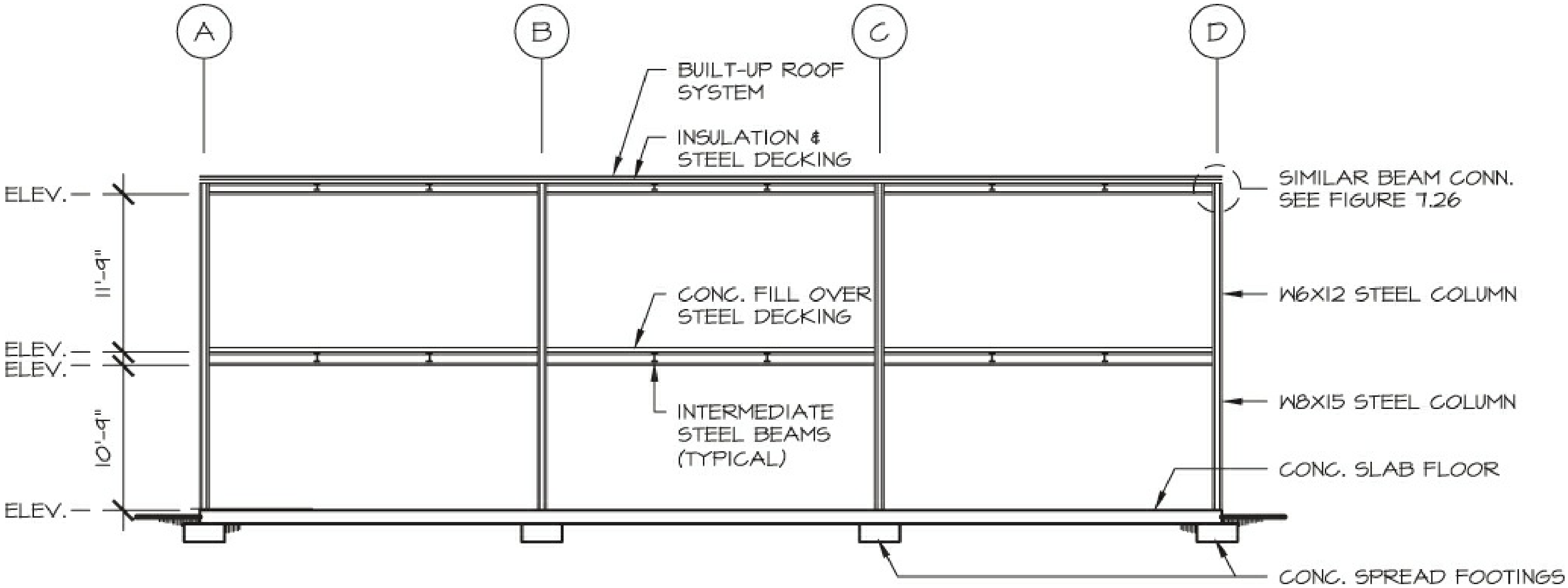


Figure 5.62 Building section.

Here, the architect decided to use a composite floor and roof system utilizing corrugated steel decking and concrete fill as indicated on the building section. As shown in Figure 5.62, dimensions are provided for the heights of the concrete floor to the bottom of the second floor and the top of the second floor to the bottom of the roof beams. This may also be achieved with the use of vertical elevations relative to the ground…floor concrete slab elevation. A pictorial view of the building section is given in Figure 5.63. A photograph taken at the job site illustrates a typical corner first…floor steel column and beam. See Figure 5.64.

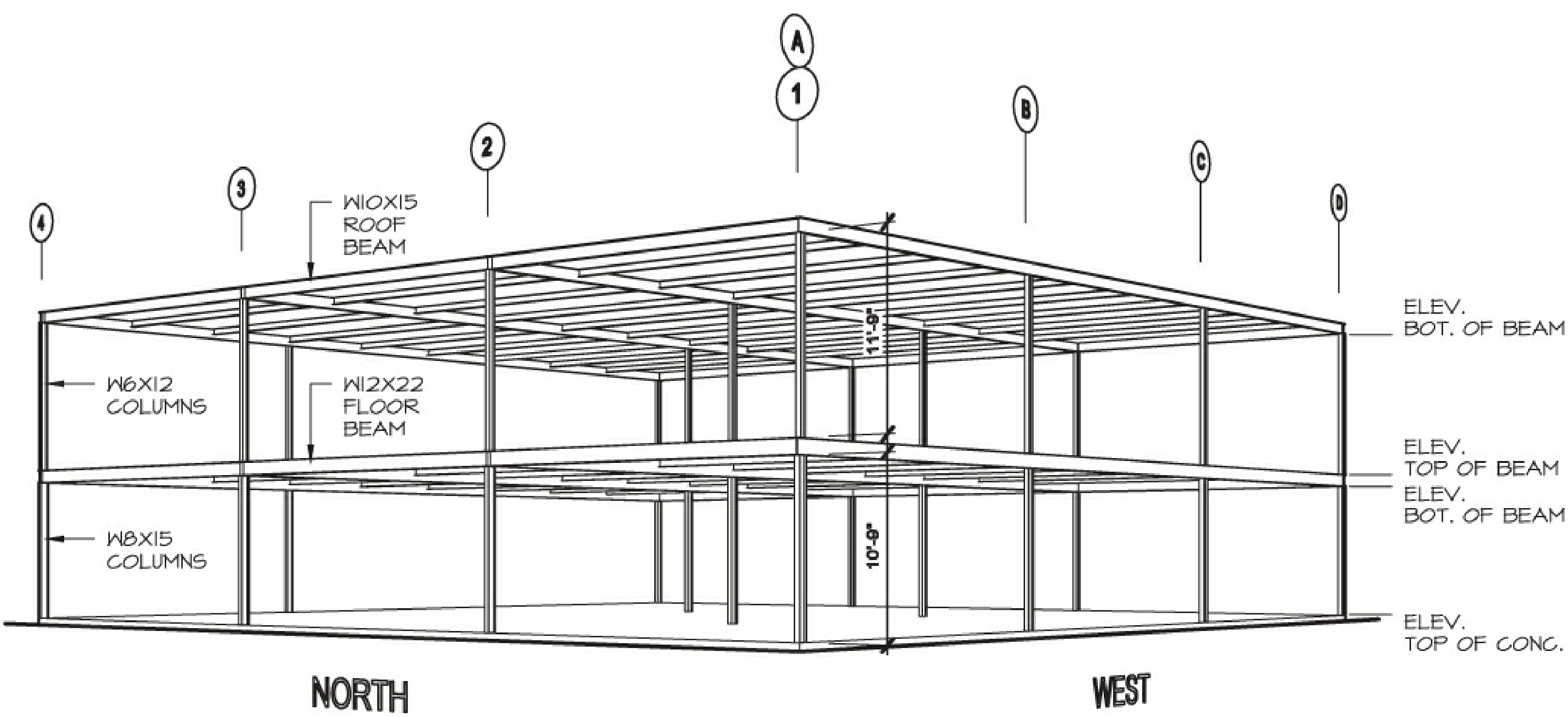


Figure 5.63 Steel frame building system.

Figure 5.64 Photograph of a similar column and beam connection.

(Courtesy of Rich Development.)

Another job site photograph (Figure 5.65) illustrates a beam and columns found along matrix line A at the first…floor level.

Figure 5.65 Photograph of ground…floor steel columns and beam.

Steel Floors

One type of steel floor system is a combination of steel decking and concrete. This type of system is referred to as a *composite* construction method. The corrugated steel decking sheets provide reinforcing for the concrete, a form into which the concrete is poured, and a walking surface for the contractors. Corrugated steel decking is available in various shapes, depths, and gauges. One method of attaching steel decking to the steel supporting

beams is with the use of steel studs welded to the top flange of the steel beams; this is done before the concrete is poured. Bonding the concrete and steel decking to the steel studs provides the structural capability to withstand horizontal shear forces. Such a composite steel and concrete floor system provides a lighter and stiffer building, as well as an assemblage of noncombustible materials. See Figure 5.66.

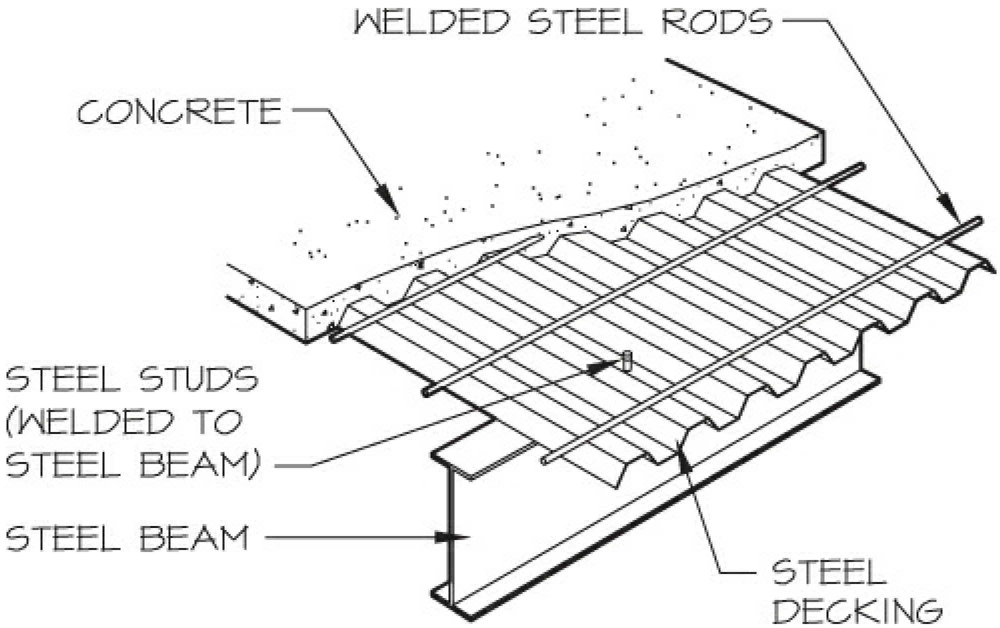


Figure 5.66 Composite steel decking floor system.

STEEL STUD WALL FRAMING SYSTEM

Steel Studs

The use of lightweight, cold…formed steel stud members provides a wall framing system for load…bearing and non…load…bearing walls. These walls provide a noncombustible support for fire…related construction and are well suited for preassembly. Moreover, shrinkage is not a concern with steel stud walls. The material of the studs varies from 14… to 20…gauge galvanized steel, with sizes ranging from 1½″ to 10″ in depth. These walls are constructed with a channel track at the bottom and top of each wall and steel studs attached to the channels. Horizontal bridging is achieved with the use of a steel channel positioned through the steel stud punch…outs and secured by welding. See Figure 5.67. Wood sheathing may be attached to steel framing members with self…tapping screws. See Figure 5.68.

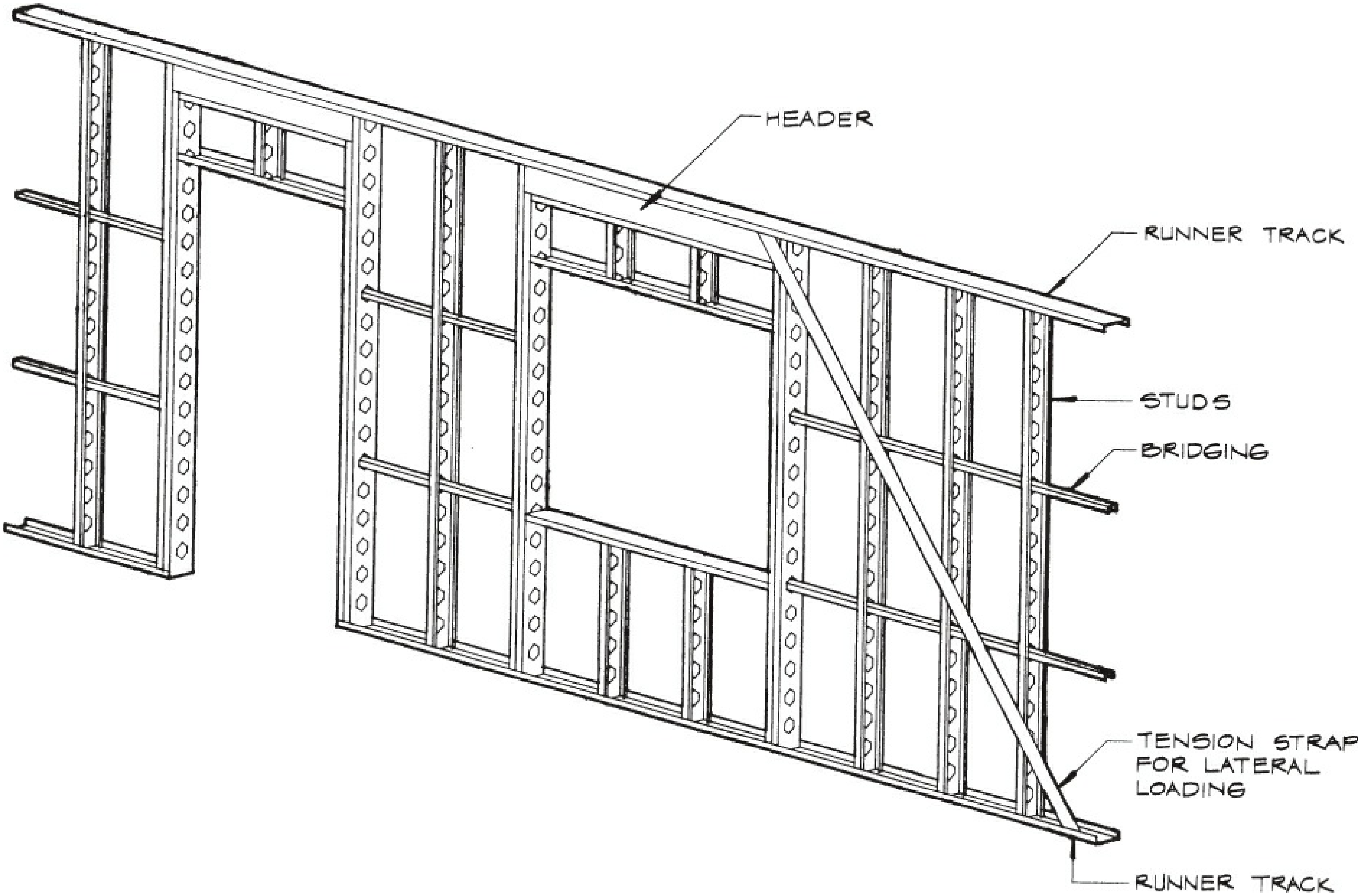


Figure 5.67 Isometric of steel stud wall.

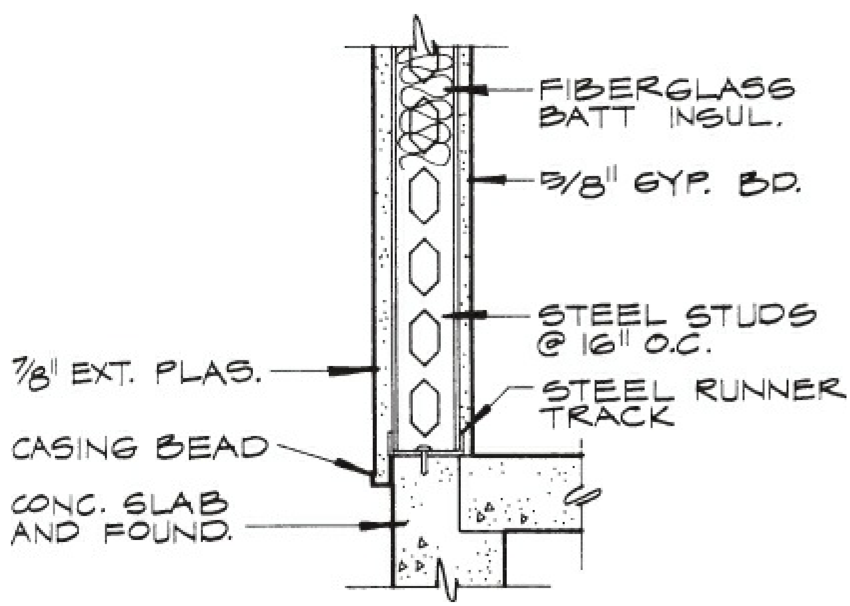


Figure 5.68 Partial steel stud wall section.

STEEL DECKING ROOF SYSTEM

Steel Decking

Corrugated steel decking used in steel roof systems is available in various shapes, with steel gauges ranging from 18 to 24 gauge and depths from 1½″ to 3″. Steel decking roof systems are mainly found in the construction of commercial, industrial, and institutional…type buildings. Figure 5.69 illustrates a roof…to…wall assembly incorporating a 20…gauge galvanized steel decking, which in this case has a fire protection coating to satisfy a building code requirement. For insulation purposes, a 2½″…thick rigid insulation board is installed directly above the steel decking, followed by installation of the built…up roof system.

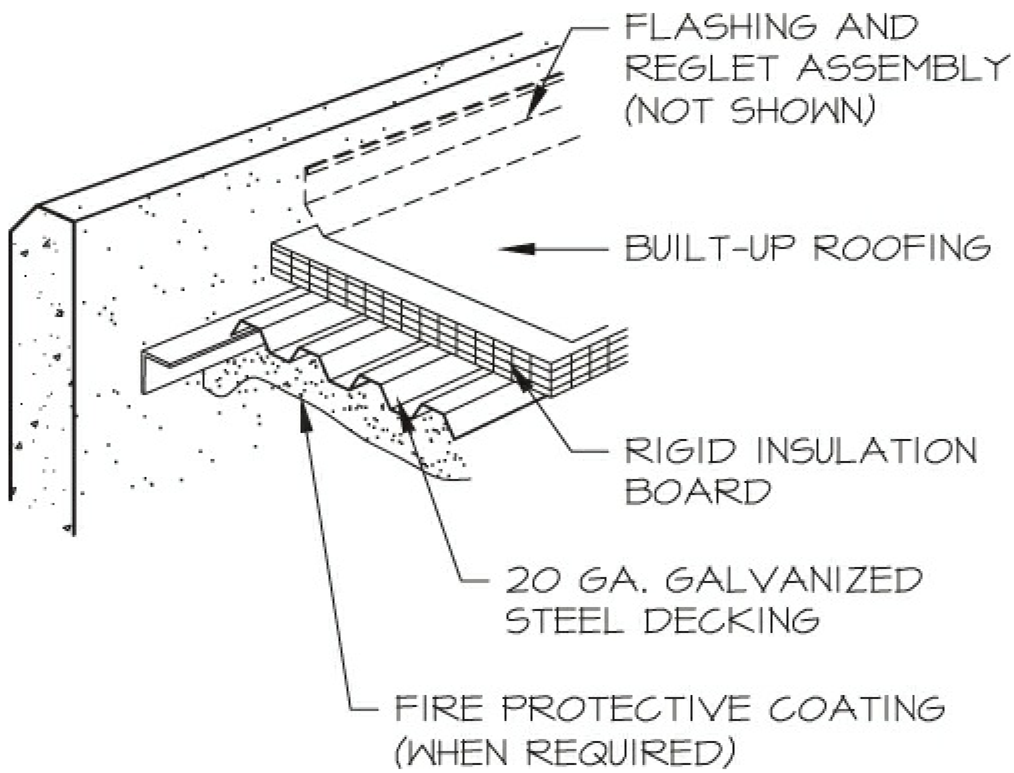


Figure 5.69 Steel roof decking system.

LIGHT STEEL ROOF FRAMING SYSTEM

Steel Framing

Light steel framing members are used in the construction of roof framing systems. These members are available in web depths of 3 5/8″ to 13½″. These light steel members are manufactured from 18… to 24…gauge steel. The attachment of plywood or OSB sheathing and other wood members may be accomplished with the use of self…tapping screws. See Figure 5.70.

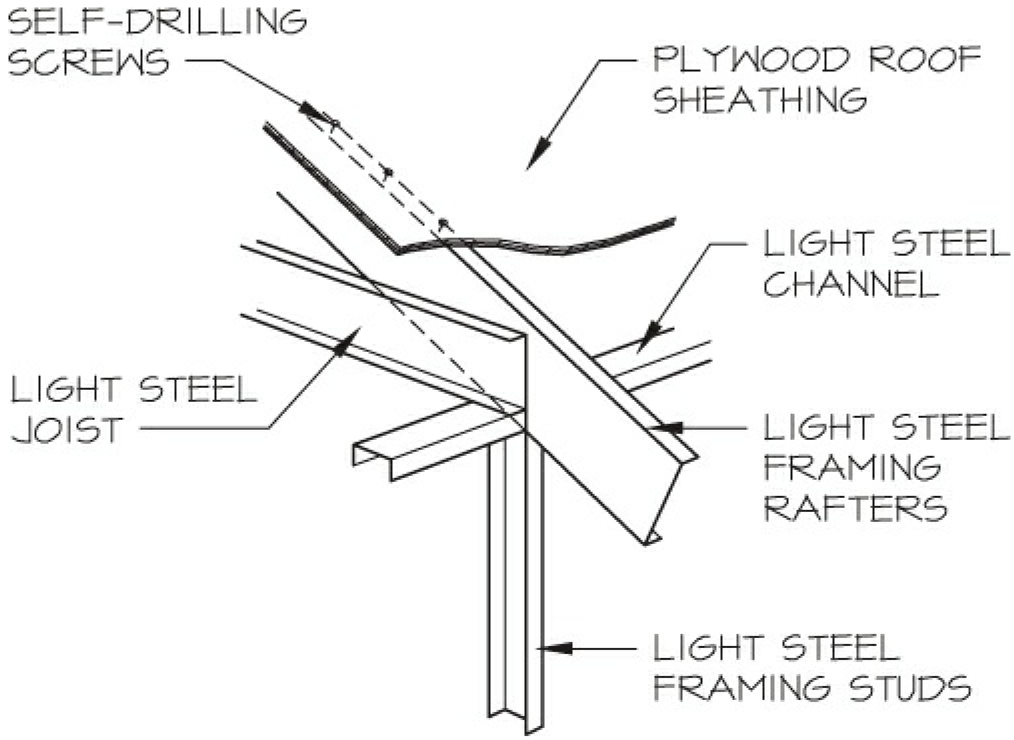


Figure 5.70 Light steel roof framing system.

MASONRY SYSTEM

Masonry

Masonry has proven to be a versatile and durable construction material. Various types of masonry products are available for the construction of buildings. In general, reinforced grouted brick masonry units and reinforced **concrete masonry units (CMUs)** are widely used in the construction of residential, commercial, and industrial structures.

Wall thickness and modular layout will depend on whether reinforced grouted brick masonry or CMUs are selected. Brick masonry units are manufactured in a great range of sizes, starting with the standard brick size of 2½″ × 31/3″ × 8¼″ and ranging to a brick block size of 75/8″ × 5½″ × 15½″. CMUs are often referred to as *concrete block units*. Though sizes vary, a typical modular concrete block unit is rectangular with dimensions of 8″ wide, 8″ high, and 16″ long.

Floor Plan

The initial approach to a floor plan layout is for the architect to select the type of masonry material that will be used in the building project. Suppose an architectural firm has selected CMUs for the exterior walls of a small industrial building, utilizing an 8″ × 8″ × 16″ modular system. This selection will now dictate the initial floor plan layout. Because the architect is dealing with a precast modular unit, he or she will delineate the exterior walls to 8″ wide while recognizing the length of the modular unit as it relates to dimensioning and wall openings. When possible, it is more practical and efficient to lay out the walls and vertical wall heights with the standard concrete block modular sizes.

This will eliminate the need to saw‐cut the concrete units, which will lessen the construction costs and save construction time.

An example of a light industrial building floor‐plan layout using 8 × 8 × 16 CMUs is illustrated in Figure 5.71. This floor plan has used standard size CMUs in order to eliminate the process of saw‐cutting any of the modular units. The dimensioning of the door and window openings adheres to the length of the modular units, also referred to as stretchers. An acceptable method of delineating CMUs in plan view is shown in the enlarged portion of Figure 5.71. A view showing a part of the floor plan is depicted in Figure 5.72.

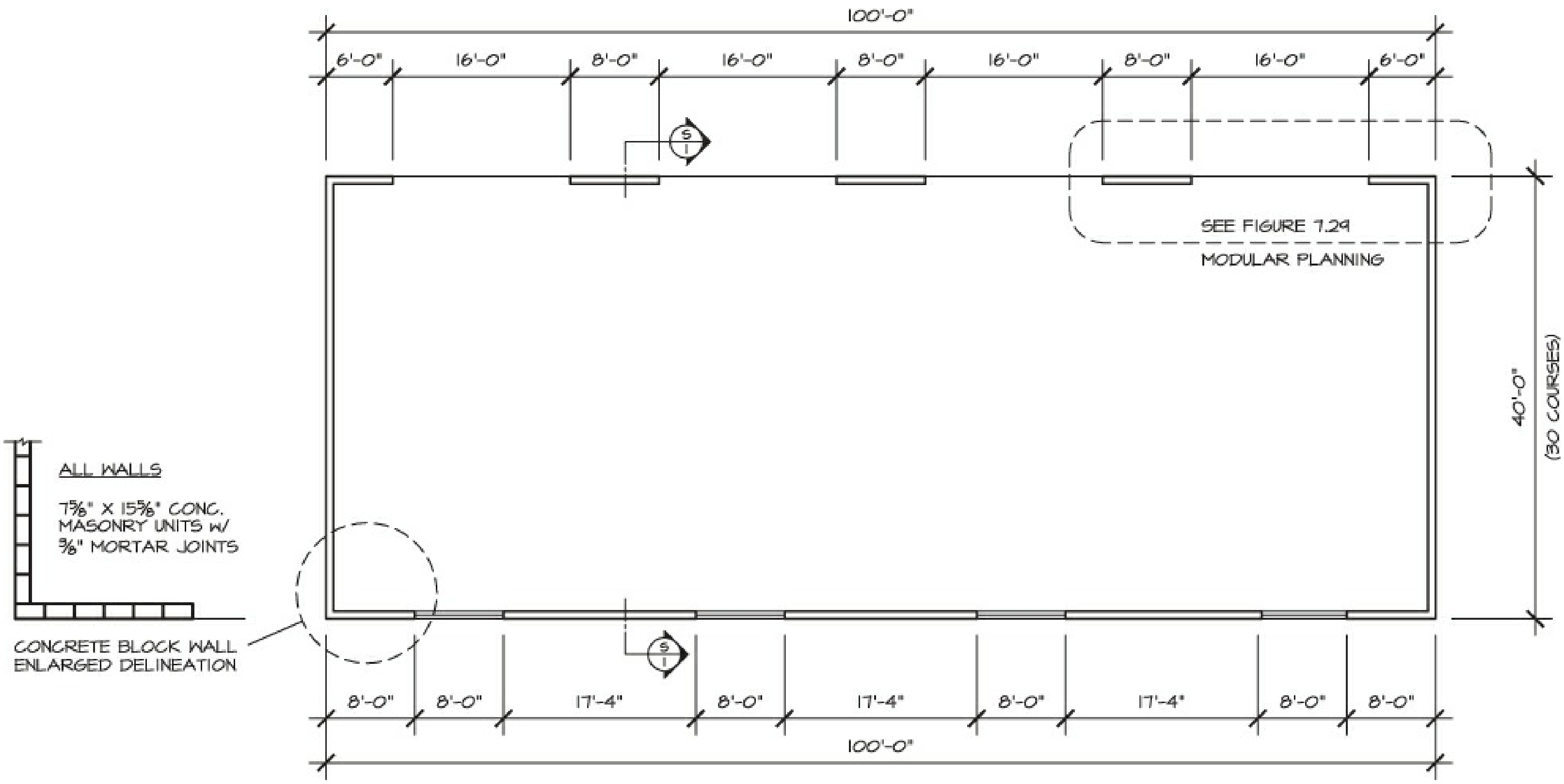


Figure 5.71 Concrete masonry modular units floor plan.

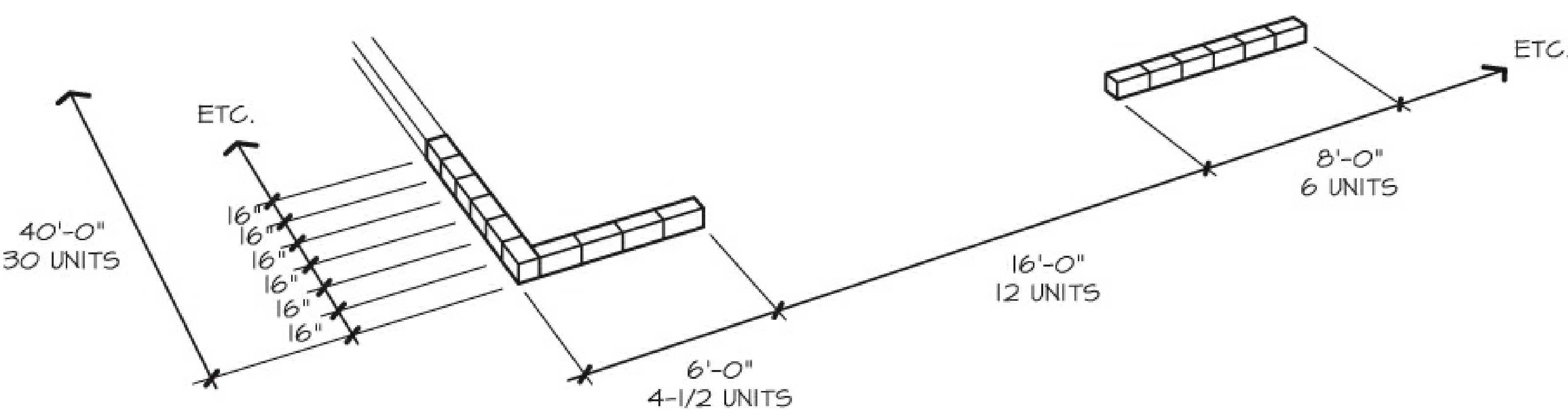


Figure 5.72 Blocks using a modular floor‐plan layout.

Exterior Elevations

It is paramount to develop and design the exterior wall heights to accommodate the height of the concrete blocks when CMUs have been selected for a project. In this case,

the CMUs are 8″ in height, and therefore a multiple of these units will dictate the height to the top of the concrete block wall. Figures 5.73 and 5.74 illustrate a wall height of 16′, which translates to 24 courses of 8″…high concrete block units. The window and door heights are also at the height of a multiple of concrete block units. In this case, the tops of the doors and windows will be at a height of 10′, which is established with the use of 15 8″…high CMUs. A pictorial view of the north and west elevations is given in Figure 5.75.

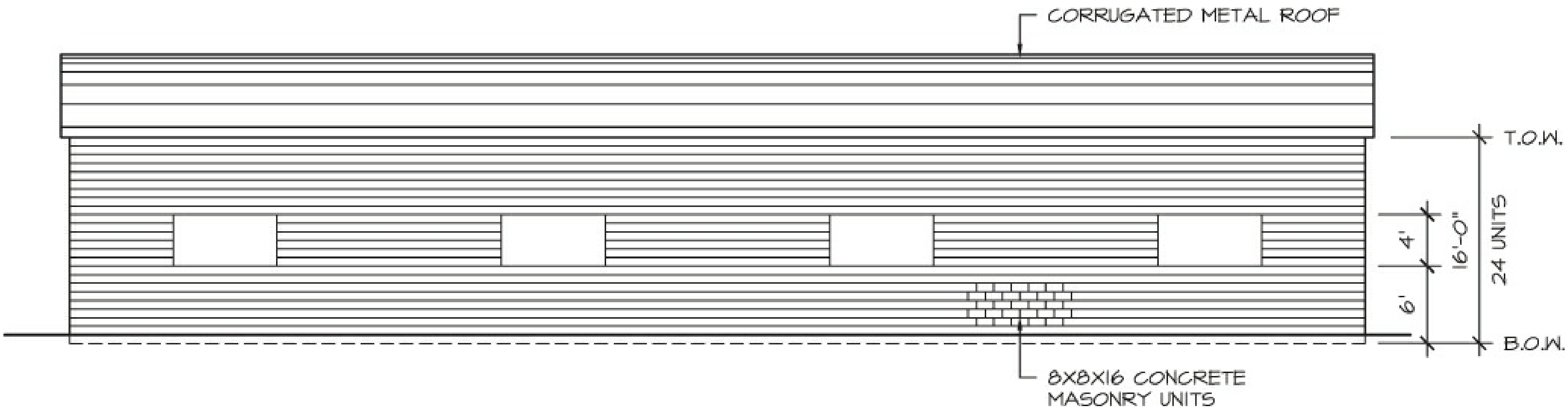


Figure 5.73 South elevation.

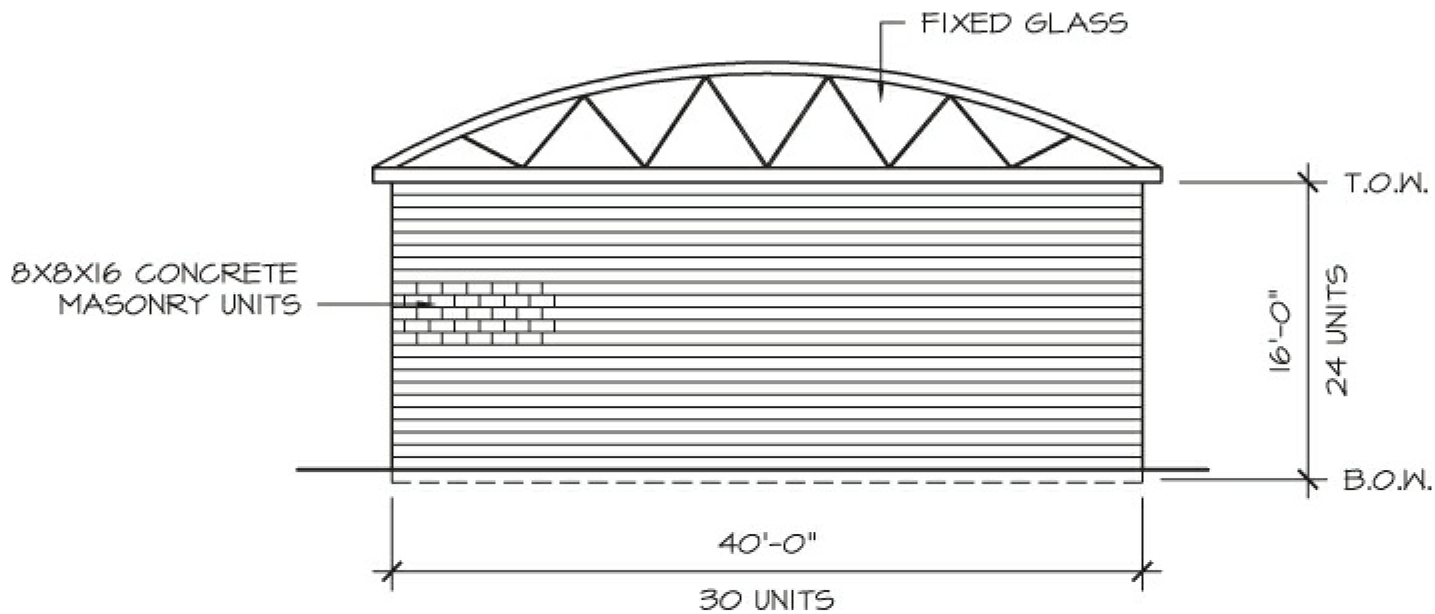


Figure 5.74 East elevation.

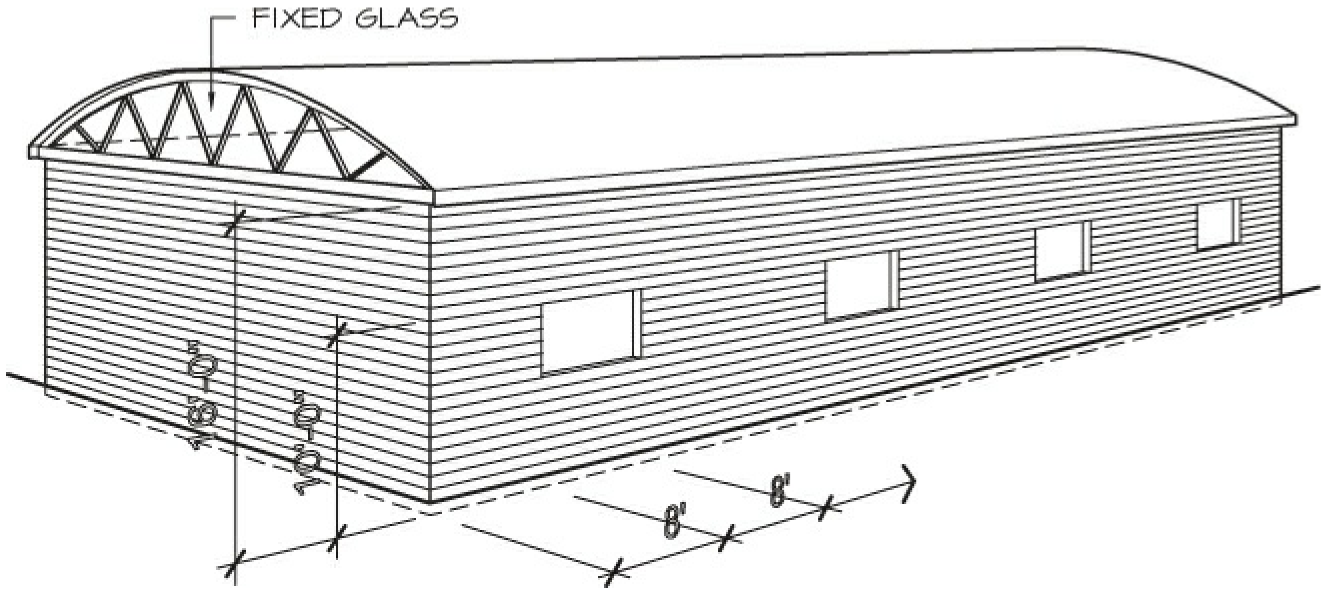


Figure 5.75 North/west elevation view.

Building Sections

The study of the preliminary building sections usually coincides with the development of the exterior elevations, in order to determine the wall heights and the wall material. The study also includes the type of roof system and its material composition. In the example of the light industrial building, a building section S…1 has been taken in the north…south direction, as indicated in Figure 5.71. This building section delineates the top and bottom of the concrete masonry wall, in which case the height of the masonry wall is established by the desired number and height of the modular CMUs. See Figure 5.76. As previously indicated, the wall height has been established by the height and number of concrete block units while addressing the requirements for this type of building. See Figure 5.76.

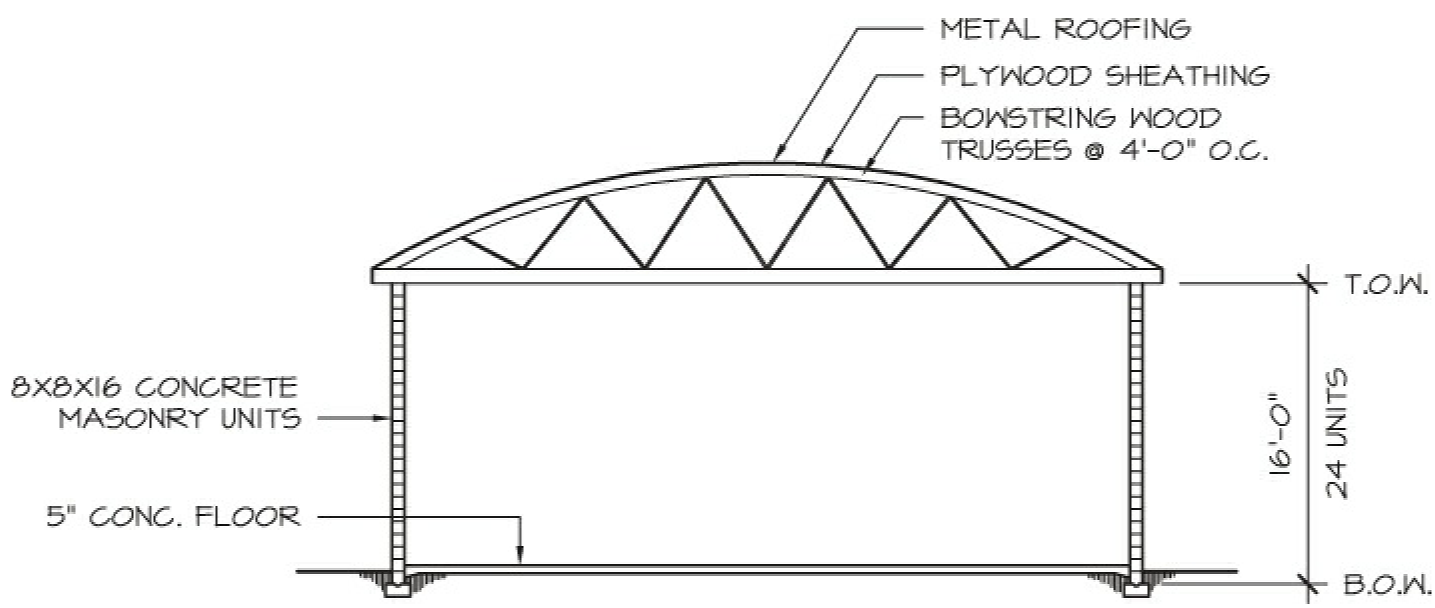


Figure 5.76 Building section S…1.

Masonry

Masonry is widely used for exterior structural walls. The main masonry units are bricks

and concrete blocks, which are available in many sizes, shapes, textures, and colors. A primary advantage is that the masonry acts as the formwork for concrete.

Masonry is fire resistant and provides excellent fire ratings, ranging from two to four hours or more. The hour rating is based on the time it takes a fire…testing flame temperature to penetrate a specific wall assembly. Masonry also acts as an excellent sound barrier. When solid brick units are used for an exterior structural wall, the primary assembly is determined by regional geophysical conditions, such as seismic activity and high winds. For example, steel reinforcing bars and solid grout may be needed to resist lateral forces. Figure 5.77 shows a steel…reinforced brick masonry wall. The size and placement of the horizontal and vertical reinforcing steel are determined by the structural engineer and the governing building code. In regions without high wind conditions or seismic activity, reinforcing steel and grout are not needed. The unreinforced masonry wall or brick cavity wall is excellent for insulating exterior walls. Two 3″ or 4″ walls of brick are separated by a 2″ air space or cavity. This cavity provides a suitable space for insulating materials, and the two masonry walls are bonded together with metal ties set in the mortar joints. See Figure 5.78.

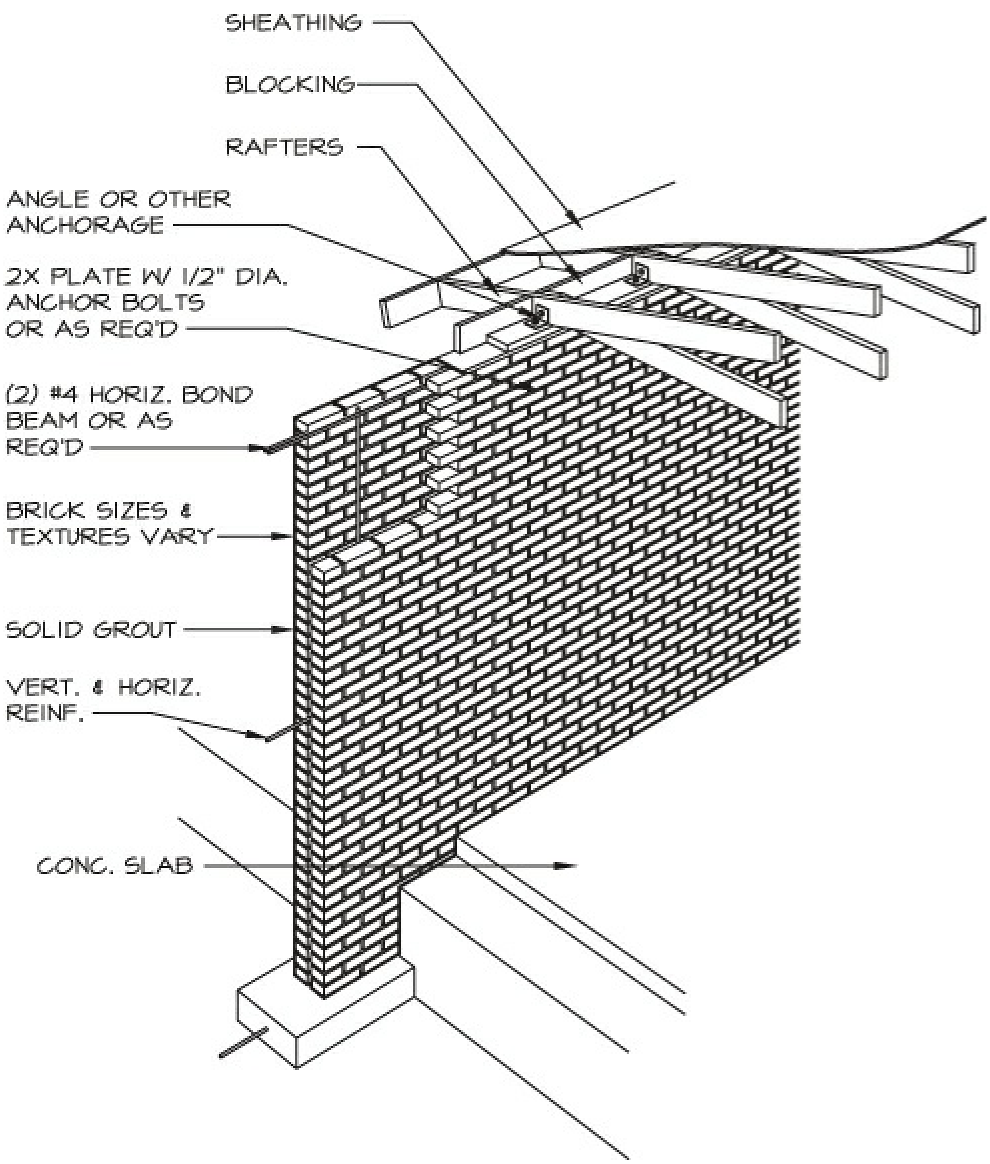


Figure 5.77 Section of reinforced grouted brick masonry wall.

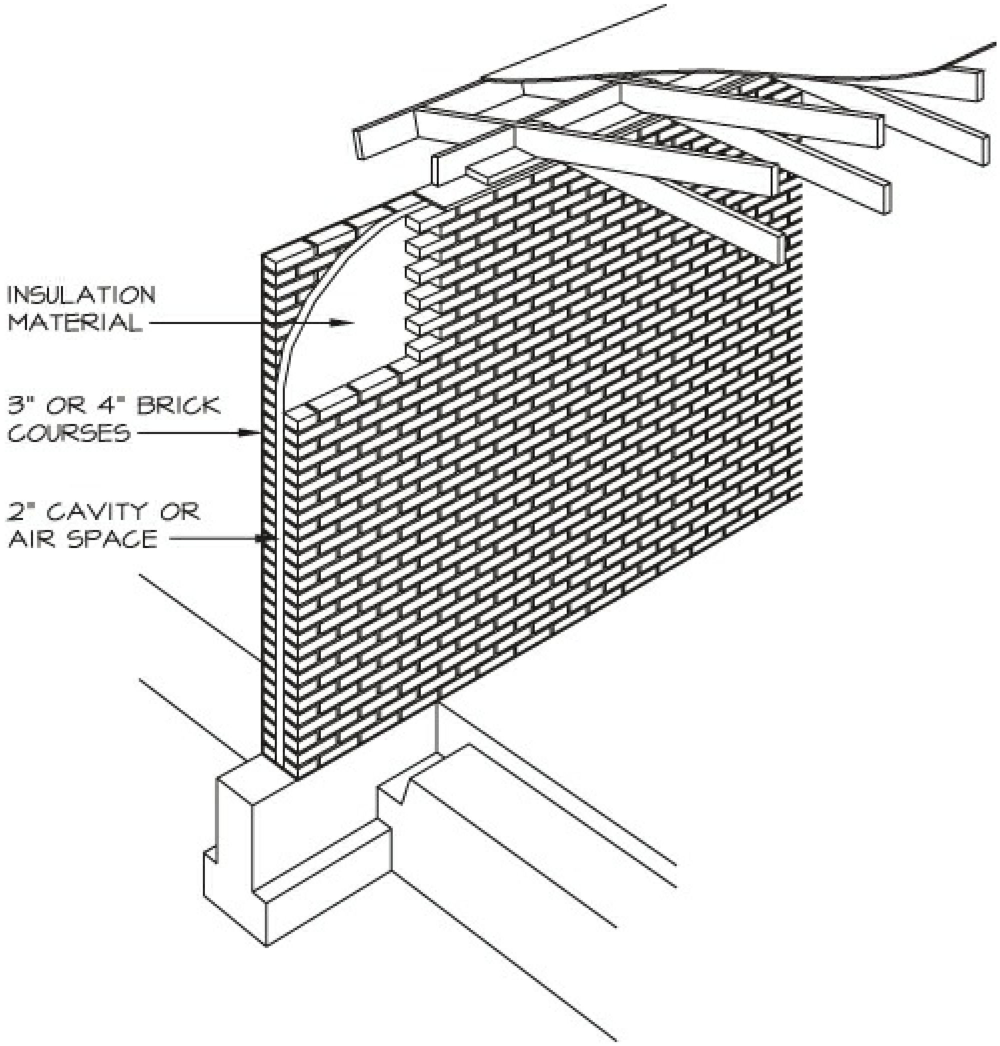


Figure 5.78 Brick cavity wall section.

CMUs for structural walls are generally 6″, 8″, 12″, or 16″ thick, depending on the height of the wall. The hollow sections of these units are called **cells**. Vertical cells may be left empty or filled solid with grout and reinforcing steel; when required, horizontal cells can also include concrete and steel to add strength. As in brick wall construction, the use of unreinforced or reinforced walls will depend on the structural engineer's calculations and the building code requirements. In regions where reinforcing steel and grout are not required, the open cells may be filled with a suitable insulating material. When you utilize a concrete block wall, the dimensions of the blocks affect the height and width of the building; it is best to utilize the modular unit of the block. See Figure 5.79. Window and door openings must satisfy the dimensions of the modular units as well.

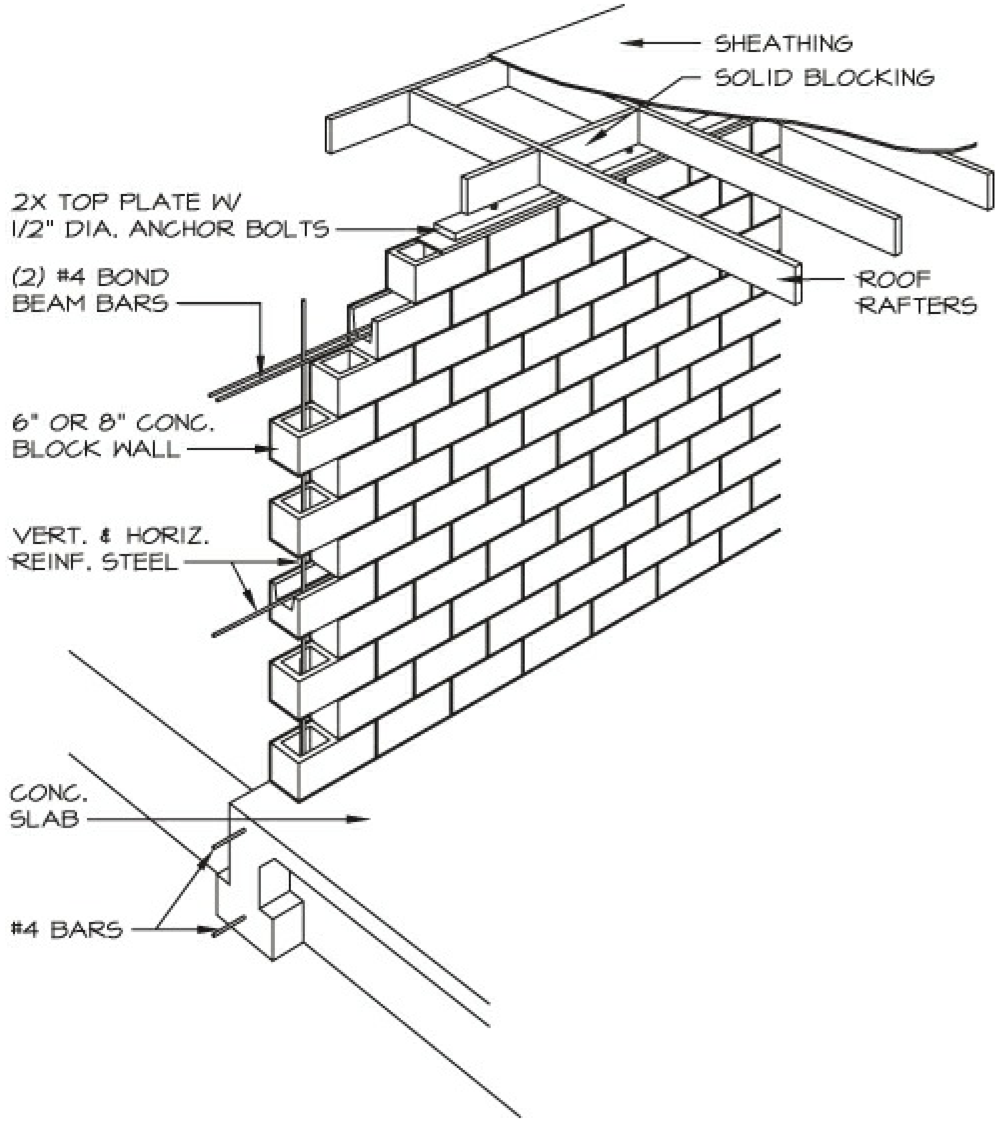


Figure 5.79 Reinforced concrete block wall section.

Masonry Veneer Wall

Masonry veneer includes the use of brick, CMU, or stone as a non…load…bearing component of the building. The maximum thickness of masonry veneer is regulated by most building codes and is generally recognized as 5″ or less. **Masonry veneer** may be defined strictly as a masonry finish that is nonstructural and generally used for its architectural appearance. In regions with seismic disturbances, a positive bond between the veneer and a stud wall is required. See Figure 5.80.

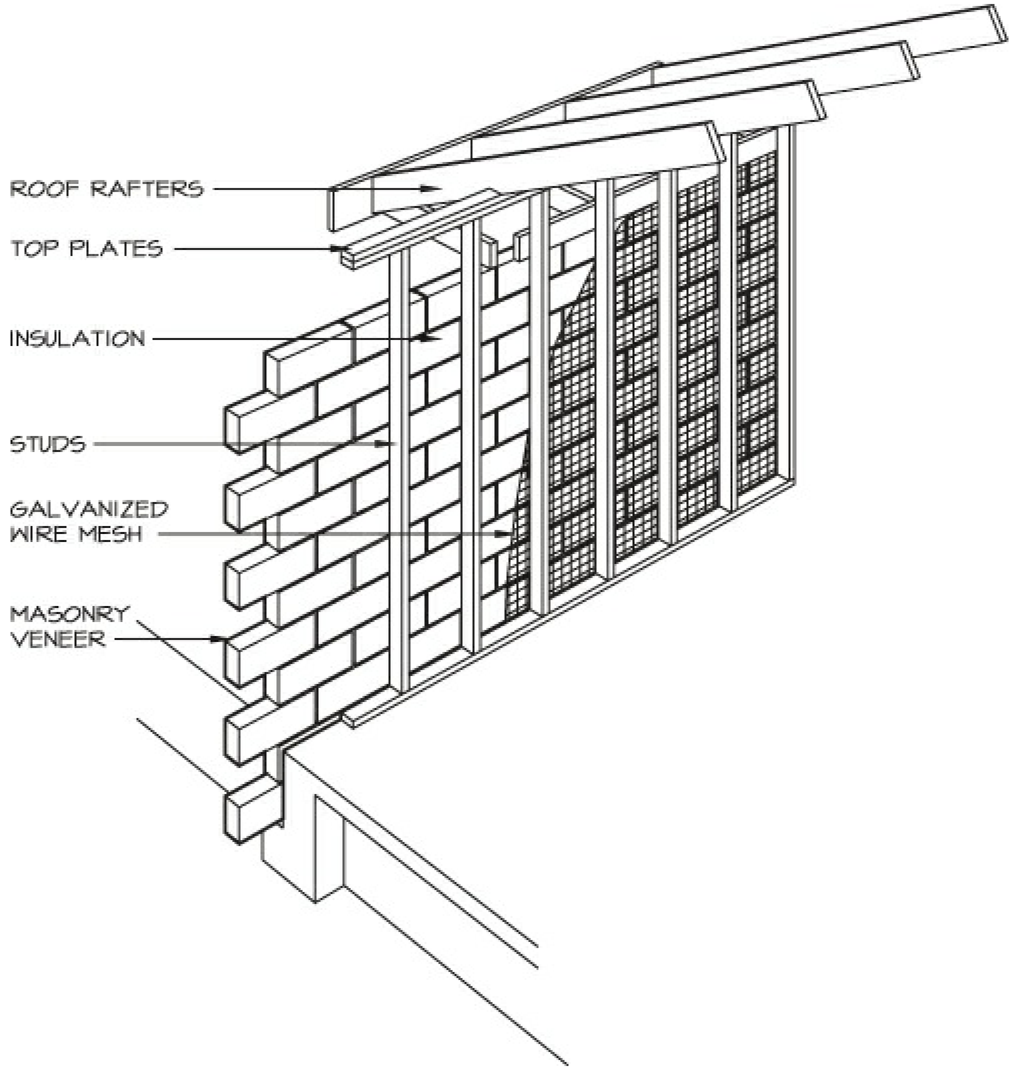


Figure 5.80 Masonry veneer detail.

COMPOSITE SYSTEMS AND COMBINATIONS OF MATERIALS

Systems and Materials

Some construction methods incorporate systems that are assembled with various materials. These are called **composite systems** and may include a combination of materials such as steel and concrete; aluminum and insulation panels; polystyrene, galvanized steel, and concrete; and plastic and wood. These are just a few of the material combinations utilized in building construction. Another example of a composite system is the use of polystyrene and galvanized steel forms for construction of poured concrete walls. See Figure 5.81. This system provides a form for the poured concrete and also possesses excellent insulation qualities, as the polystyrene forms are retained in the structural wall. They are designed to serve as an anchor for the finish materials that will be applied to the exterior and interior faces of the wall. The exterior and interior finishes may be anchored to galvanized steel furring strips that are an integral part of the form unit. Figure 5.82 depicts a single polysteel form unit.

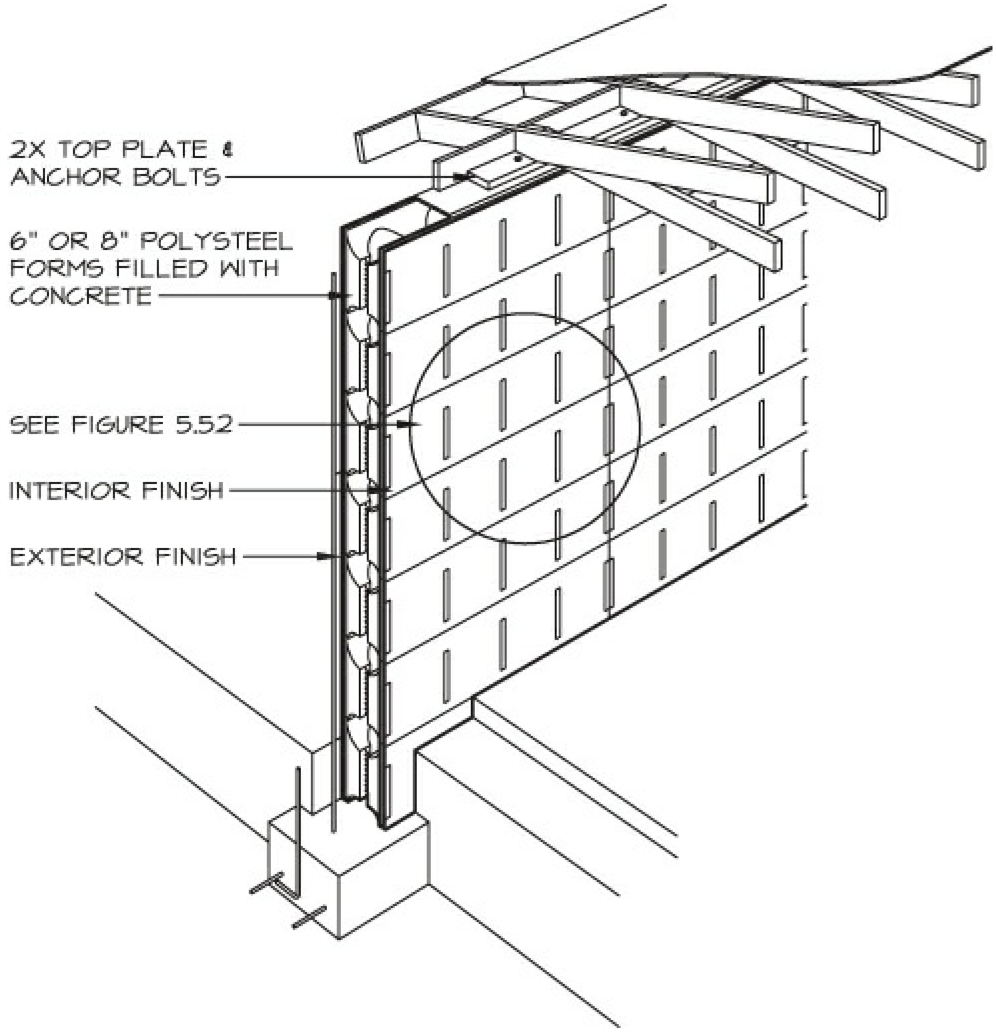


Figure 5.81 Polysteel forms and concrete wall.

(Courtesy American Polysteel, Inc.)

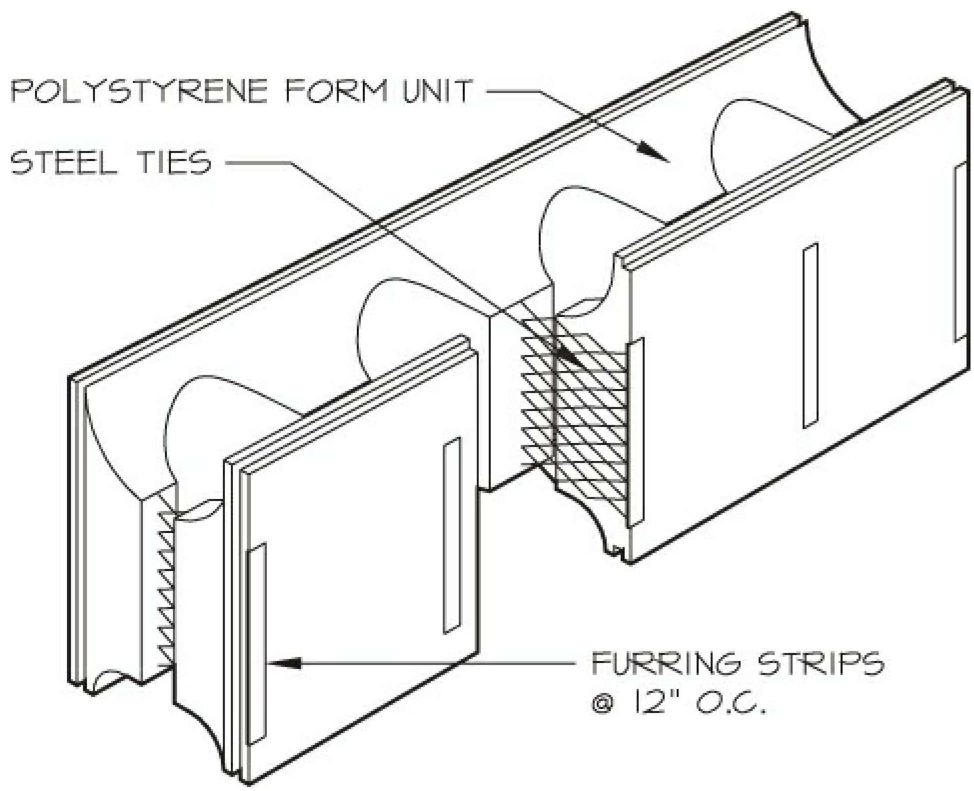


Figure 5.82 Polysteel form unit.

(Courtesy American Polysteel, Inc.)

For structures that are designed to have exterior wall insulation, the architect may select a composite exterior wall system that utilizes a substrate material insulation board and a moisture…proof exterior finish. The thickness of an acceptable substrate may be at least ½″, and an expanded polystyrene insulation board may be from 1″ to 2″ in thickness. The selected thickness may be determined by the required or desired R factor. (The R factor designates the assigned insulation capability.) It is recommended that the supporting exterior wall members for this system be galvanized steel studs at 16″ center to center or 24″ center to center. This composite system can be attached to the steel studs and the approved substrate with an approved adhesive or a mechanical attachment. The mechanical attachment incorporates a metal screw and washer. See Figure 5.83.

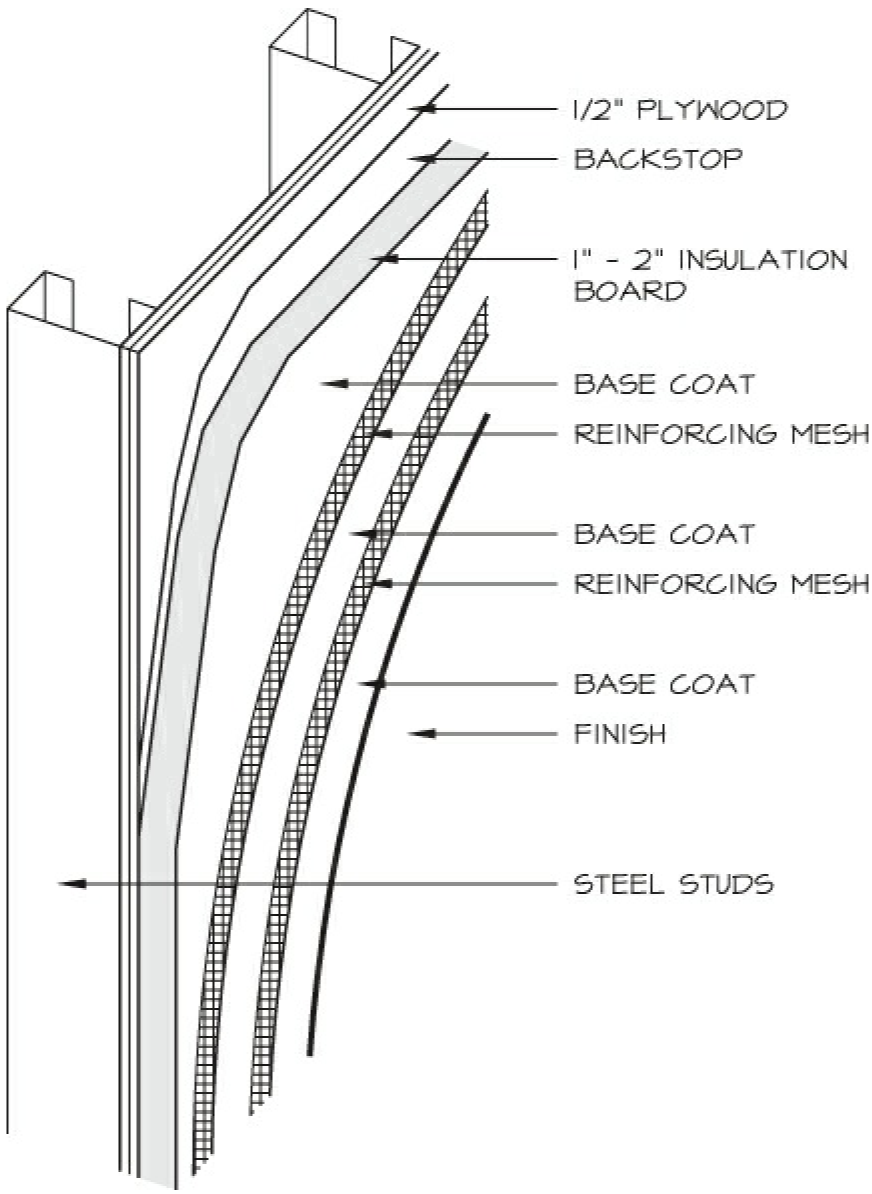


Figure 5.83 Composite wall panel.

(Courtesy of Dryuit Systems, Inc.)

Figure 5.84 illustrates an exterior wall assembly utilizing the aforementioned wall panel. Note that the polystyrene selected is 2″ thick. The parapet detail in Figure 5.85 incorporates the various requirements for using this system.

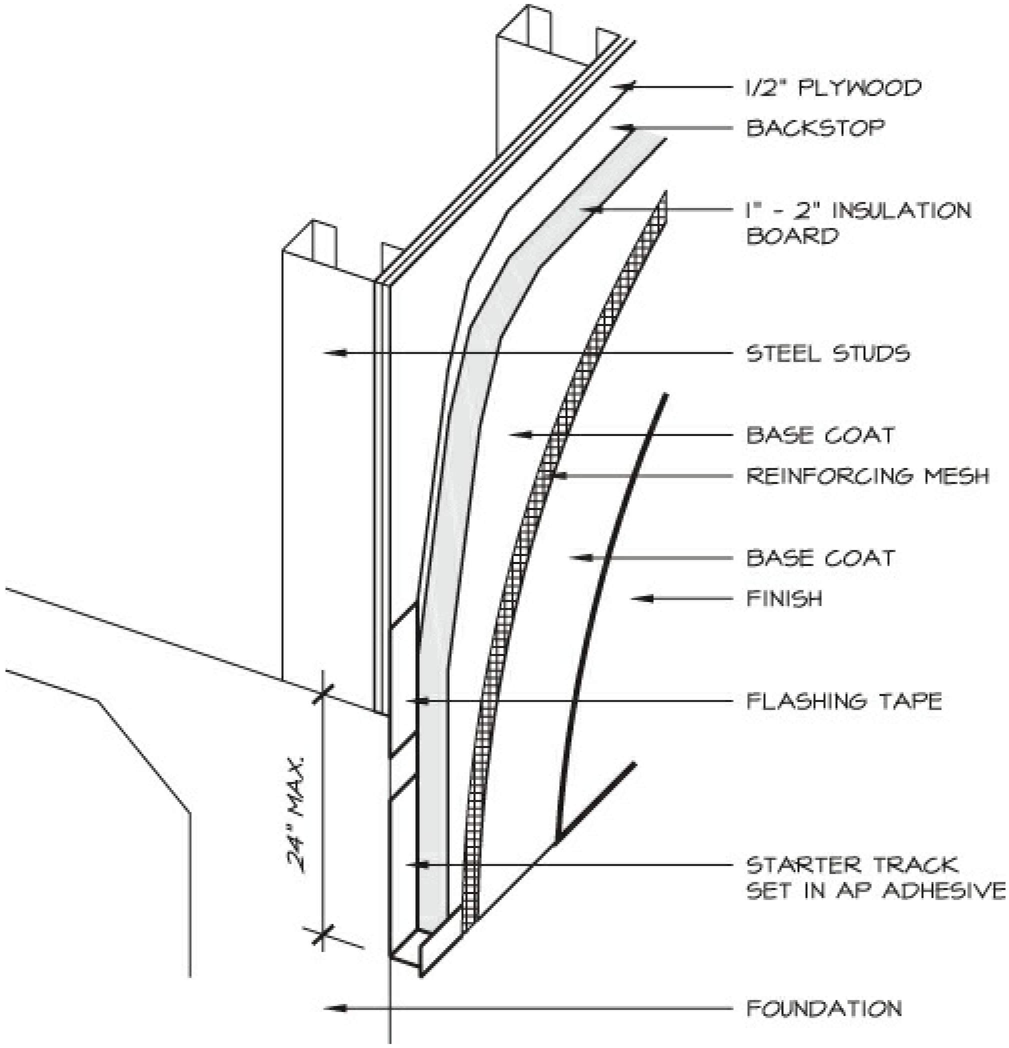


Figure 5.84 Composite wall panel attachment.

(Compliments of Dryuit Systems, Inc.)

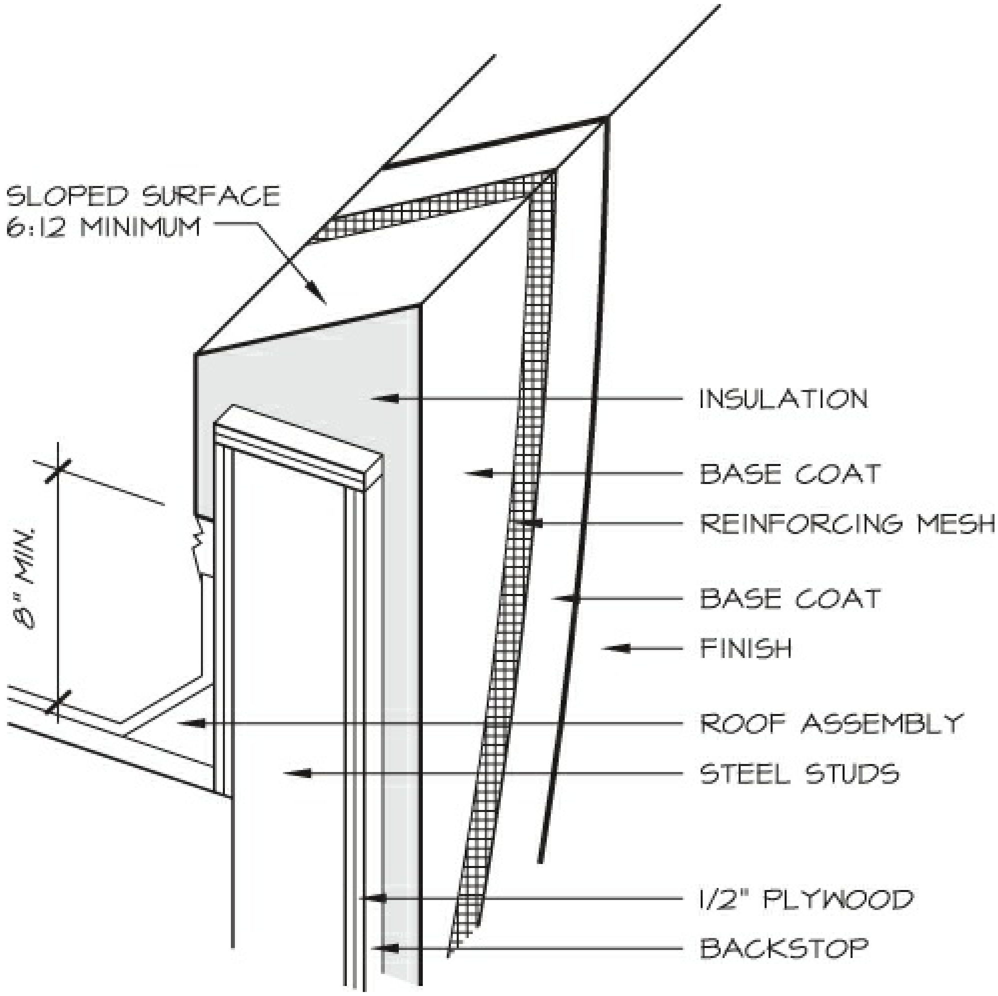


Figure 5.85 Composite parapet detail.

(Compliments of Dryuit Systems, Inc.)

Wood and plastic are found in a product developed for exterior decking and handrails in construction. This composite product requires virtually no maintenance and is manufactured from a sturdy wood composite. The decking material will not splinter, split, or crack; is resistant to termites, dry rot, and decay; and is available in a wood…like finish. The individual members are straight and true, having a smooth or wood…grain finish. The members can be attached using the same method as for sawn lumber; however, predrilling and the use of screws are recommended. This decking material is available in two types. One is a solid 4 × 6 unit that can be supported with structural members spaced at 16″ center to center. The other type is a 2 × 6 unit that is hollowed to provide a lighter weight for ease of handling. The hollowed member may span over the joists spaced at a maximum of 24″ center to center.

These two products do not require painting, staining, or sealing. Because all members are of exactly the same size and shape, the installation process is made easier. See Figure 5.86.

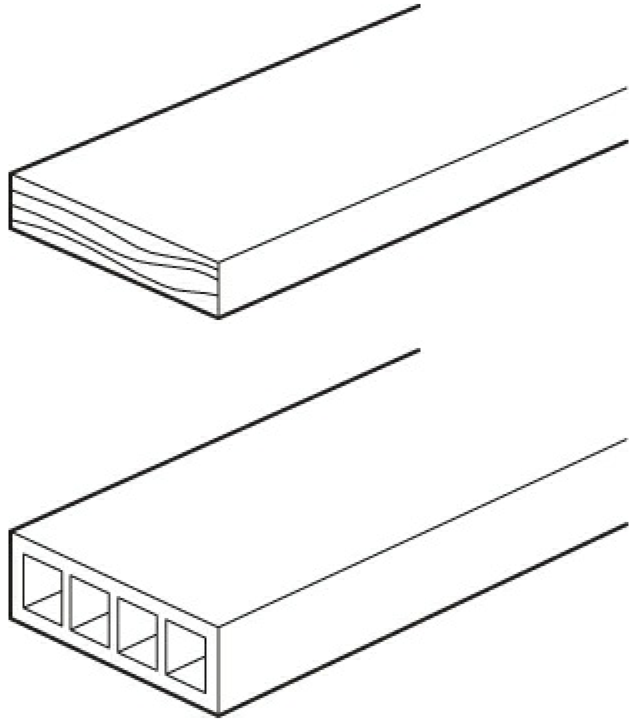


Figure 5.86 Composite decking members.

The composite handrail system incorporates 2 × 6 handrails, 2 × 4 side rails, and 2 × 2 balusters. The use of screws with countersunk…type heads is recommended for connection of the various members. All screws must be predrilled. The composite handrail system is depicted in Figure 5.87. This handrail assembly shows the various member sizes that are available for construction of an exterior handrail system. See Figure 5.88.

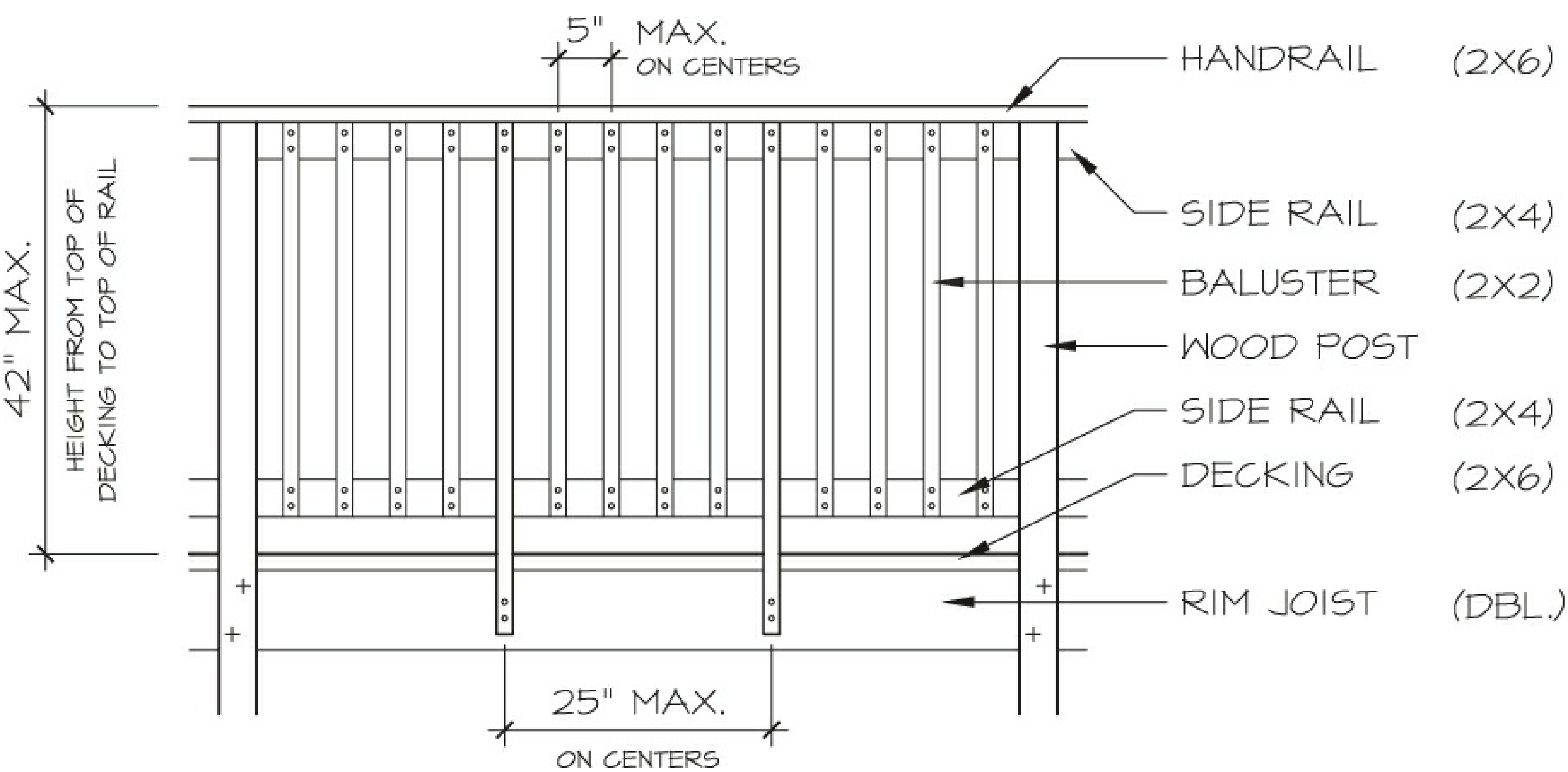


Figure 5.87 Composite handrail system.

(Courtesy of Louisiana Pacific Corp.)

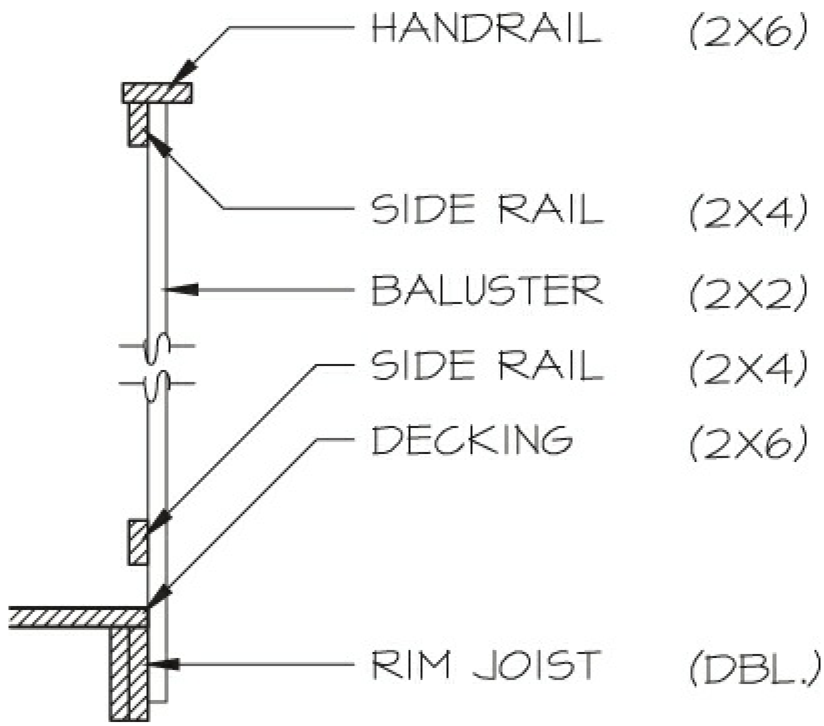


Figure 5.88 Section through handrail.

One of the first composite insulated concrete forms (ICFs) was introduced to the architectural world in Austria in 1972. Millions of these units have been built throughout Europe, the Far East, North Africa, and the Americas. With a corporate office in Arizona, Rastra would be a good company for an architectural designer to research. Look at Figure 5.89, which shows a typical Rastra unit, and Figure 5.90, which shows a Rastra system section found on its web site.

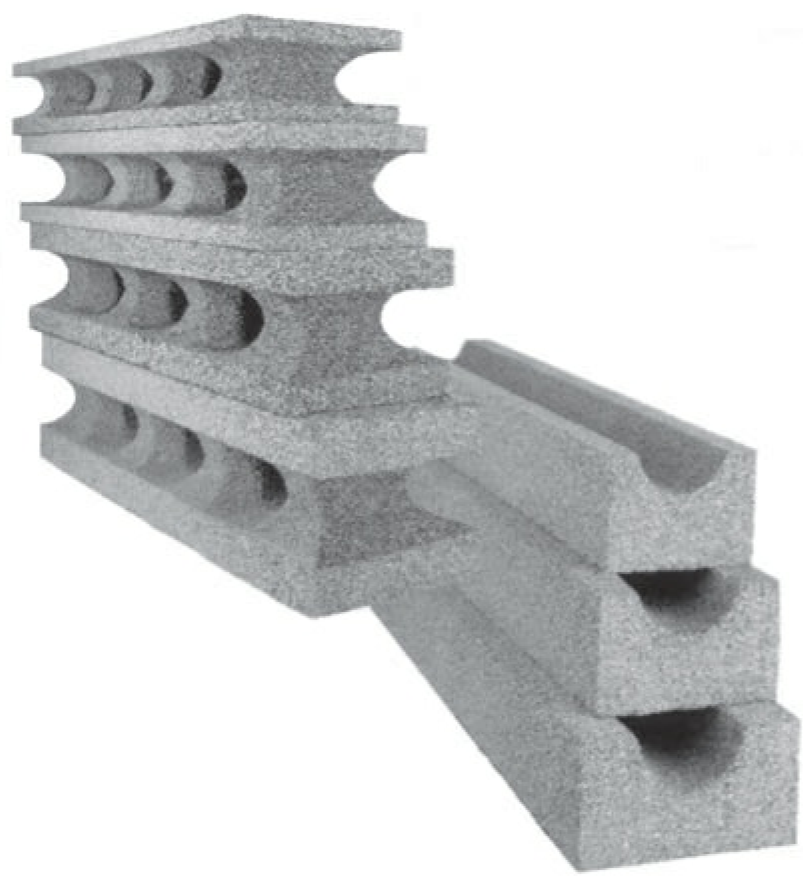


Figure 5.89 Rastra modules.

(Courtesy of Dorothy Taylor and James Buttram.)

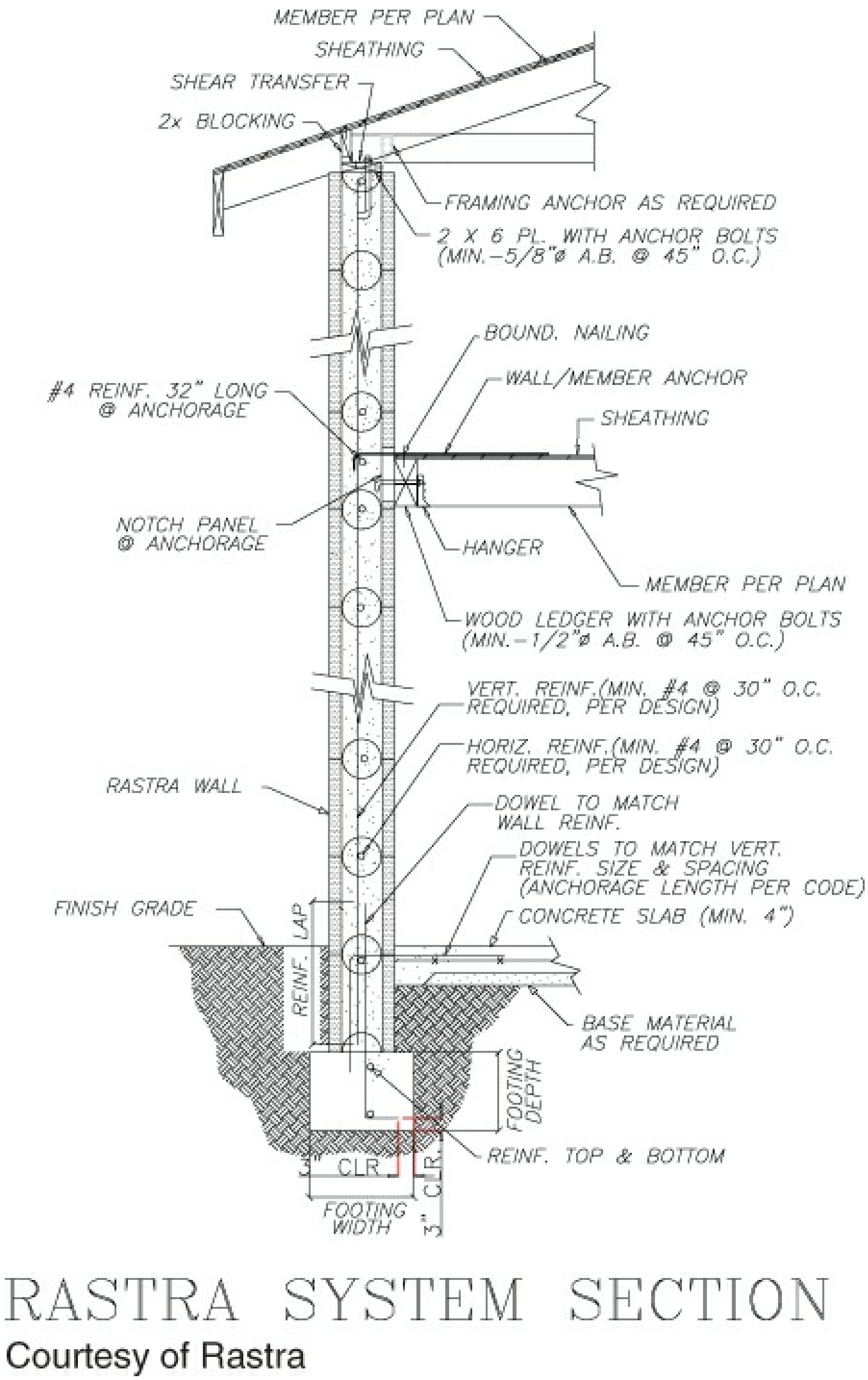


Figure 5.90 Rastra system section.

(Courtesy of Dorothy Taylor and James Buttram.)

Now let's look at a project under construction. Figure 5.91 shows the beginning phases of construction. The entire perimeter of the house is built with Rastra and the interior with steel upon which concrete was poured to form the floors. The interior walls are built with a framework of steel, upon which drywall was mounted and finished. See Figures 5.92 and 5.93, which show the progress of the single‥family home built by the owner couple.

Figure 5.91 Rastra module in progress.

(Courtesy of Dorothy Taylor and James Buttram.)

Figure 5.92 Rastra module in progress.

(Courtesy of Dorothy Taylor and James Buttram.)

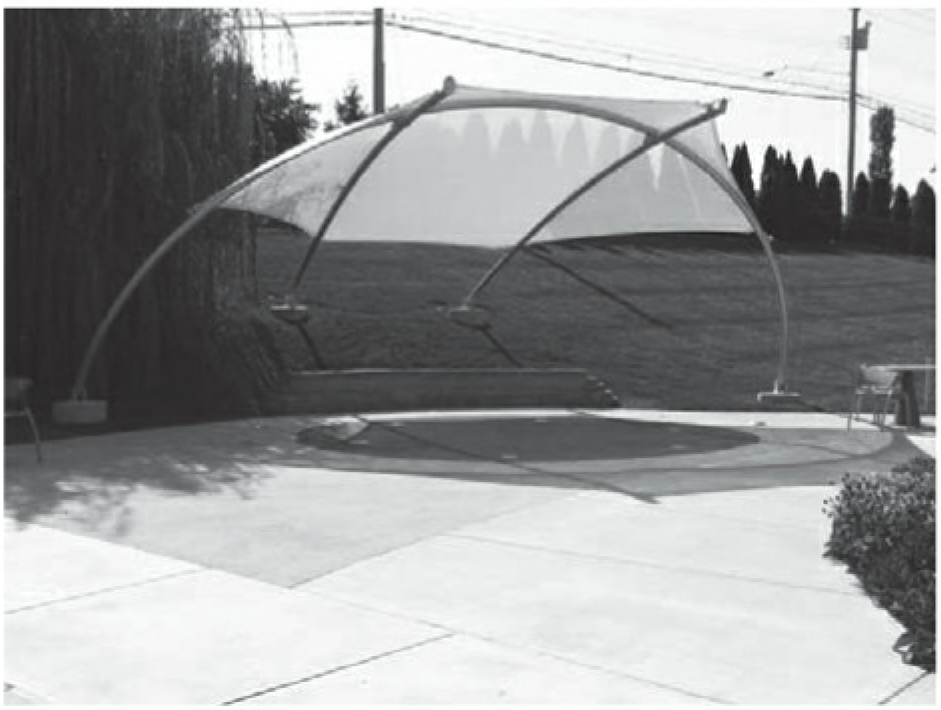
Figure 5.93 Finished Rastra structure.

(Courtesy of Dorothy Taylor and James Buttram.)

Tensile Structure Awnings and Canopies

A unique form of architectural structure is what is known as *tension structure*. Picture your hands holding a rope and pulling it apart. This is the concept of using the strength of a material—in our case, steel. If it helps you can visualize a rubber band being stretched this pull apart action is called tension. Often used in conjunction with canvas, one can span large areas such as shown in Figure 5.94 A and B. The first of these figures shows a large span covering the bleachers adjacent to the stadium, and the second shows a possible outdoor eating area.

A



B

Figure 5.94 Tensile structures.

(Courtesy of Lawrence Fabric & Metal Structures, Inc.)

Awnings are used to extend a roof plane to shade a particular area or a series of windows.

See Figure 5.95 A through C.


mapes
ARCHITECTURAL CANOPIES
www.mapescanopies.com

Ⓐ


mapes
ARCHITECTURAL CANOPIES
www.mapescanopies.com

Ⓑ


mapes
ARCHITECTURAL CANOPIES
www.mapescanopies.com

Ⓒ

Figure 5.95 Awnings.

(Courtesy Mapes Architectural Canopies.)

As shown in Figure 5.96A, canopies can be used to highlight the entry of a building. They do not have to be a semicircle, but rather any geometric configuration one may wish to enhance an area. They can highlight a firm's name, such as those shown in Figure 5.96 A and B, or to define the entry of a large corporation, such as shown in Figure 5.96C.


Office DEPOT
www.mapescanopies.com
mapes
ARCHITECTURAL CANOPIES

Ⓐ


THE METRO
2121 DELGANY
www.mapescanopies.com
mapes
ARCHITECTURAL CANOPIES

Ⓑ

Ⓒ

Figure 5.96 Canopies.

(Courtesy Mapes Architectural Canopies.)

Key Terms

cells

composite systems

concrete masonry units (CMUs)

concrete retaining wall

dimensional reference system

engineered lumber

masonry veneer

monolithic system

net size

one…pour system

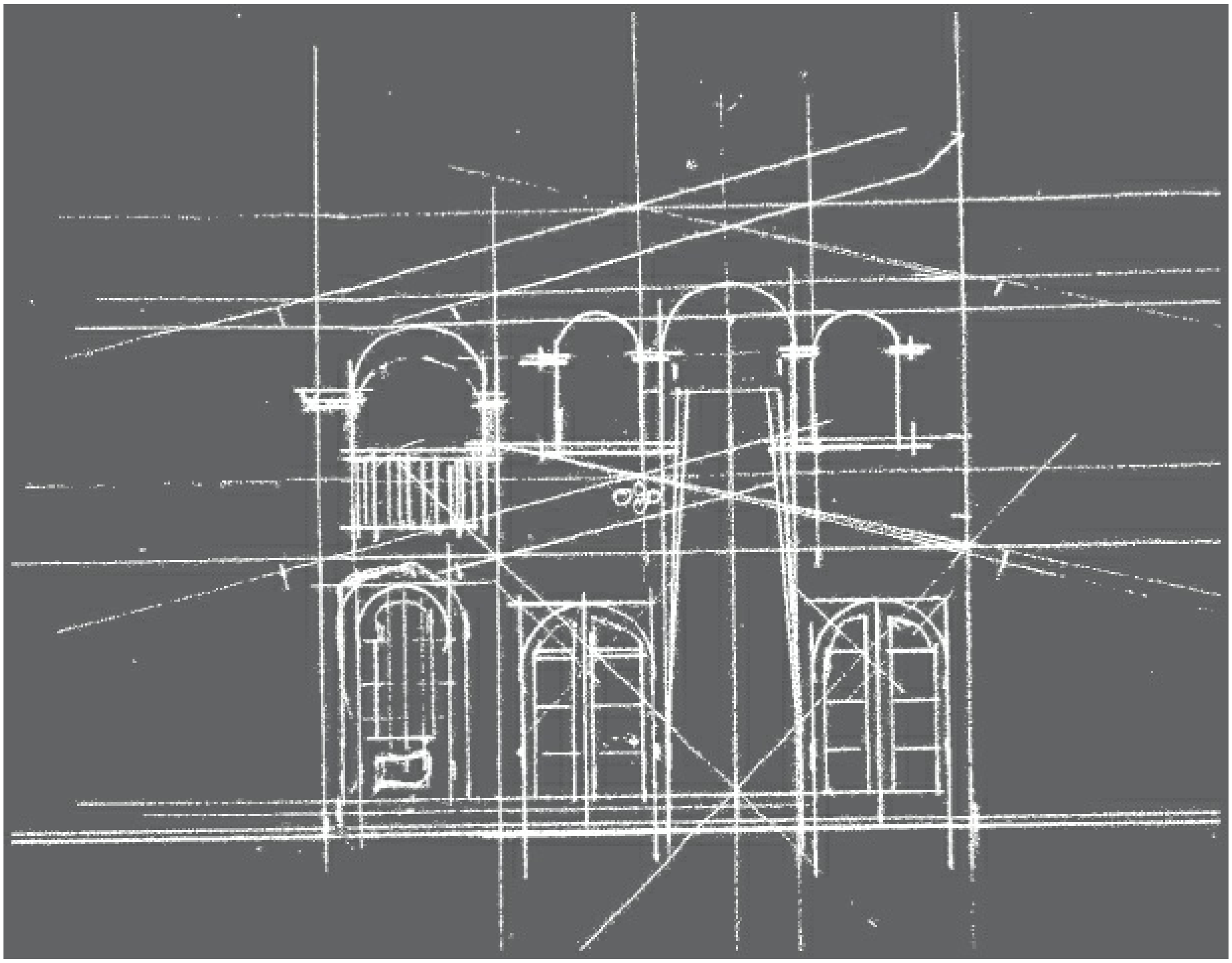
oriented strand board (OSB)

planking

two…pour system

two…way flat slab

Chapter 6
INITIAL PREPARATION PHASE FOR CONSTRUCTION DOCUMENTS



GUIDELINES FOR CONSTRUCTION DOCUMENTS

Construction Documents

Guidelines are too important to reduce to a series of steps and formulas to memorize. In fact, working guidelines for drafting are actually attitudes and ideals that are fundamental to good communication that will result in a smooth project. You may think that much of this material is obvious, common knowledge, or common sense. They have been arrived at through research in supervision, communication, human relationships, and field experiences, particularly with prospective employers. Remember, in an architectural firm you are not an individual; rather, you are an important part of a team, and as a team member, you must know how the team functions.

The Rules for Drafting Construction Documents

1. Plan the steps of your required drawings.
2. Establish a system in which you can check your work.
3. Understand the implications of decisions you make.
4. Know and understand the standards under which you will function.
5. Draft with an understanding of the other person's point of view.

6. Cooperate, communicate, document, and work with others.
7. Find out your primary and secondary responsibilities.
8. Think for yourself.
9. Concentrate on improving at least one aspect of your skills with each task.
10. Be sure to follow established office standards.

The Rules for Drafting Construction Documents, Expanded

1. *Plan the steps of your required drawings*. Each drawing has a distinct procedure and order. Make mental and/or written notes about the sequence and anticipated problems. Every sheet of a set of architectural plans subscribes to a basic system. The system may be based on the materials used, methods of erection, limits of the present technology, or even the limits of the builder, to mention a few. Whatever the controlling and limiting factors are, be aware, understand, digest them intellectually, and put them into effect. Know your options when you have an unusual problem.
2. *Establish a system in which you can check your work*. Every office has some method of checking drawings. Whatever the system, establish a method to check yourself before you submit a drawing to a senior in the firm. This does two things: It builds trust between you and your supervisor. If you are conscientious enough to double… check your work, the rapport built between you and your supervisor will be enhanced. In addition, it builds the supervisor's confidence that you have done your best to perform your duty.

   This checking method differs with each person and each drawing. Accuracy transcends all checking systems—accuracy of representation as well as of arithmetic, grammar, and spelling. Nothing causes as many problems in the field as contradictory information, arithmetical tools that are not equal to their parts, or dimensions that do not reflect an established module.
3. *Understand the implications of decisions you make*. Know what decisions you will be allowed to make, and know when to ask a superior.

   If you ask a superior for help every time you are confronted with a decision, you are taking up that person's valuable time, reducing the superior's effectiveness, and demonstrating that you are not really ready for the job. Nevertheless, a production draftsperson cannot simply change a design decision; the draftsperson may not be aware of all the factors that led to that decision. It might seem obvious to the draftsperson that a particular change would produce a better effect, but the original may have been based on a code requirement, a client's request, cost of production, or any one of hundreds of reasons of which the draftsperson may not be aware.
4. *Know and understand the standards under which you will function*. You will encounter a multitude of standards. Just as there are various standards for office attire, ethics, and behavior, so there are drawing standards.

Certain offices use certain sheet sizes. Title blocks, border lines, and sheet space allocation are usually set up in advance. In fact, some offices produce what is called a manual of “office standards.” The standard may call for something as simple as a font style, or as professional as a standard based on building erection procedures. You must incorporate this standard into your documents.

5. *Draft with an understanding of the other person's point of view*. Your work involves many individuals who will interpret your drawings: people like the subcontractor, the client, and the contractor. All of these people influence your approach. For example, when you draft for the subcontractor, your work becomes a medium of communication between the client's needs and the individuals who construct and execute the structure to meet those needs. Before drafting a detail, plan, or section, you must sufficiently understand the trades involved.

   It is better to spend a few minutes with your supervisor at the beginning of a drawing, outlining your duties and the firm's objectives and needs, than to spend countless hours on a drawing only to find that much of the time you have spent is wasted.

   If you know of a better solution or method, verify its appropriateness with a superior before you employ it.

6. *Cooperate, communicate, document, and work with others*. One of the main criticisms from employers is that employees do not know how to work as members of a team. Whereas education requires you to perform as an individual, each person in an office is a member of a team and has certain responsibilities, duties, and functions on which others rely. There may be many people working on a single project, and you must understand your part and participate with others toward achieving a common goal.

   Write memos and notes, write formal letters to other companies, and document correspondence. Keep in mind that you are a representative of your firm and that proper presentation, grammar, spelling, and punctuation reflect the abilities of the firm.

   Communication helps you know what the other people in the firm are doing, and it helps you to develop an appreciation of the attitudes, goals, and aims of the others with whom you will be working. Know what is going on in the office and allow others to easily track your progress.

7. *Find out your primary and secondary responsibilities*. Nothing gets an office or an employee in as much trouble as making assumptions. Phrases such as “I thought John was going to do it” not only break down the communication process in an office but can create discord that disturbs office harmony and breaks down office morale.

   Know your responsibilities and how and whom to ask for guidance in case of a change in your responsibilities.

   A classic example of this was an office that had two divisions: an architectural division

and a structural engineering division. On the architectural drawings there were notations that read, “See structural drawings for details.” The details were never drawn, and when the total set was assembled and the lack of details was discovered, the omission caused a great delay and much embarrassment to the firm.

Whenever more than one person works on a project, you need to understand not only your primary responsibilities but your not…so…obvious secondary responsibilities as well.

8. *Think for yourself*. There is a natural tendency for a draftsperson to feel that all decisions should be made by a superior. However, your supervisor will tell you that certain decisions have been delegated to you.

   Your immediate supervisor or head draftsperson is earning two to five times as much as you are because of additional responsibilities and experience. Therefore, each time you ask a question and stop production, the cost is that of your salary plus that of your supervisor.

   Look through reference and manufacturers' literature, construction manuals, similar projects, reference books, and so on. Make a list of problems and questions and work around them until your superior is free and available to deal with them. THINK and be able to propose solutions or suggestions yourself.

   Above all, do not stop production and wait around for a superior to become available; employers react very negatively to this.

9. *Concentrate on improving one aspect of your skills with each task*. Constantly improve your speed or your accuracy. Work on your weakest aspect first, even though the tendency is to avoid or shy away from it. For example, if sections are your problem, view and study various sections from the office, texts, or publications.

   An employer wants an employee who is punctual, dependable, and accurate; has a high degree of integrity; and is able to work with a minimum amount of supervision.

10. *Be sure to follow established office standards*. Office standards are an integral part of the evolution of construction documents. It is not sufficient merely to follow the standards; it is also necessary to understand why they are used. Layer titles, basic symbols, and conventions, while simple to implement, must be the same from a Los Angeles office to a New York office.

TRANSITIONING FROM SCHEMATIC DRAWINGS TO CONSTRUCTION DOCUMENTS

Making the transition from approved schematic drawings to design development drawings to construction documents is important because it completes the process of making decisions about the physical characteristics of the building. When utilizing building information modeling (BIM), this system does not vary.

Accomplishing this transition—the design development phase—requires that the following basic requirements be satisfied and thoroughly investigated:

1. Building code, green code, and other requirements, such as those set by the zoning department, fire department, health department, planning department, engineering department, environmental department, and architectural committees
2. Primary materials analysis and selection
3. Selection of the primary structural system and materials
4. Requirements of consultants, such as mechanical, electrical, plumbing, and structural engineers
5. Regional and environmental considerations
6. Energy conservation considerations and requirements
7. Budget alignment
8. Project programming

BUILDING CODE REQUIREMENTS

Building codes exist to establish the minimum requirements for life safety. Components of a code cover areas such as exiting, fire resistivity, occupancy, sustainability, and disability access. Although some things are specified in great detail, such as the maximum rise of a stair and the minimum depth of a tread, some aspects are more general, such as a requirement of two exits for a specific occupancy group. An understanding of these codes aids the architect in the decision…making process.

It is extremely important that you research building code requirements, as they are updated regularly and new requirements are implemented. In multiple housing projects as well as in residential projects, building codes establish minimum physical requirements for various rooms. Figure 6.1 shows the minimum floor areas and dimensions required for the bedroom and kitchen.

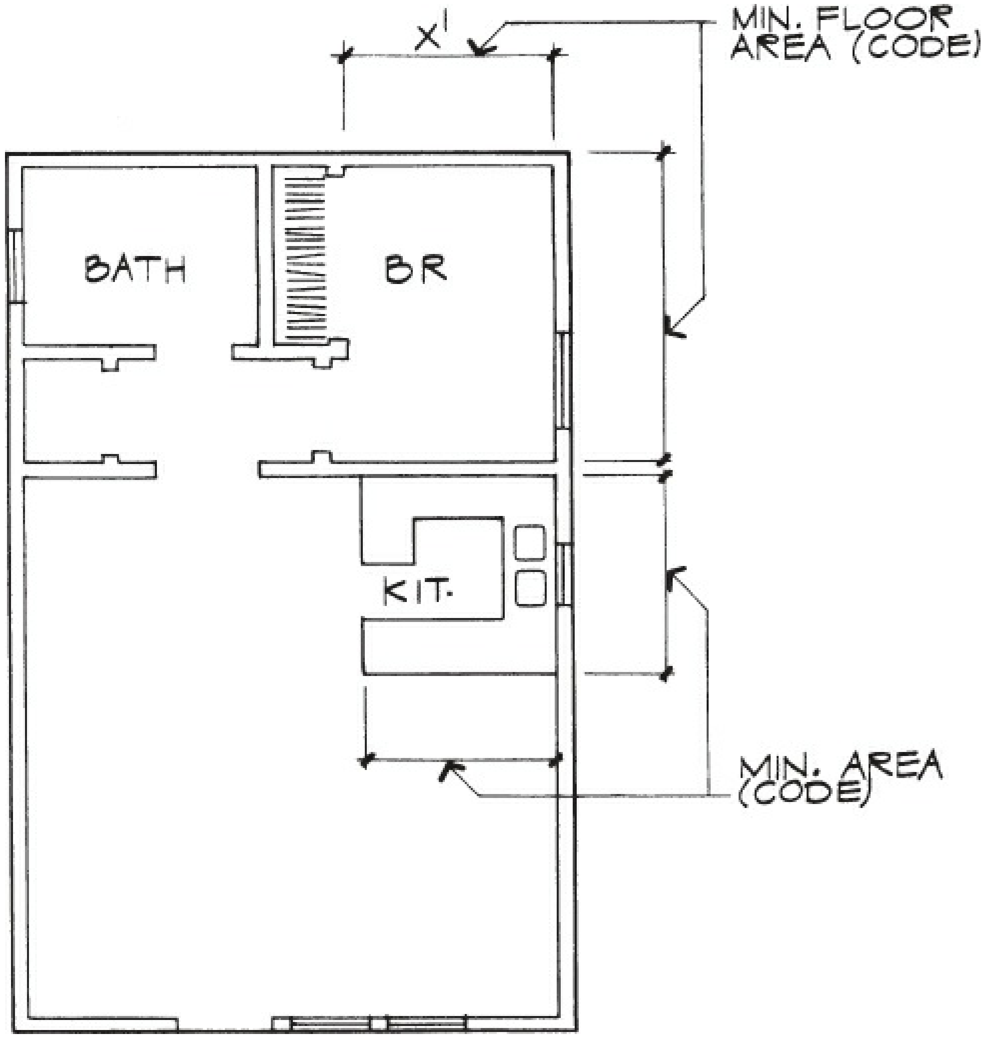


Figure 6.1 Required minimum dimensions.

Remember that the building department sets minimum standards. An architect sets standards (often above minimum) to satisfy or enhance health and safety. For example, the maximum slope for a disability ramp is 1:12. An architect may choose to use 1:14 as the slope of the ramp to be more accommodating to the individual using a wheelchair.

A new integration of sustainable architecture is becoming a larger part of the code requirements. The direction of green or environmentally friendly design is less driven by common sense and under more scrutiny by public officials. Currently, the review process is fundamental; as time passes, there will be added pressures for architects to exceed the green code minimums. As in all good design, it should be your goal to surpass the demands of city review and address the demands of good design with the incorporation of environmental design.

Material Analysis

In any building project, among the most important building materials to be selected are those for foundations and floors, exterior and interior walls, and ceiling and roof structures. Several factors influence this selection, and many of these require considerable investigation and research:

1. Architectural design

2. Building codes
3. Economics
4. Structural concept
5. Region
6. Ecology
7. Energy conservation

The importance of selection is illustrated in Figure 6.2. Concrete masonry units have been selected as the material for the exterior walls of a structure. Using this material affects the exterior and interior dimensions, because concrete blocks have fixed dimensions. Establishing the exterior and interior dimensions *before* the production of construction documents is most important because other phases, such as structural engineering, are based on these dimensions.

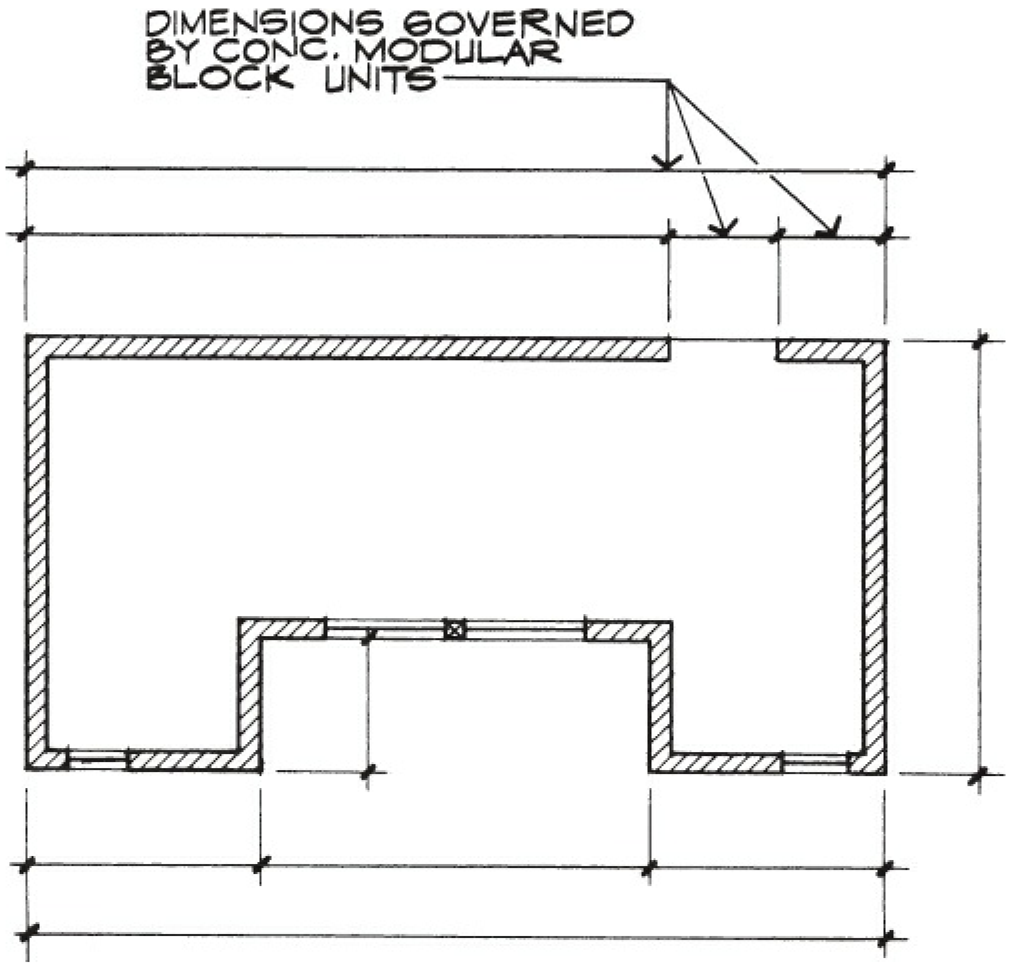


Figure 6.2 Exterior concrete block walls.

The importance of selecting primary building materials is further shown in Figure 6.3. The roofing material selected here actually governs the roof pitch. This, in turn, establishes the physical height of the building and also dictates the size of the supporting members relative to the weight of the finished roof material.

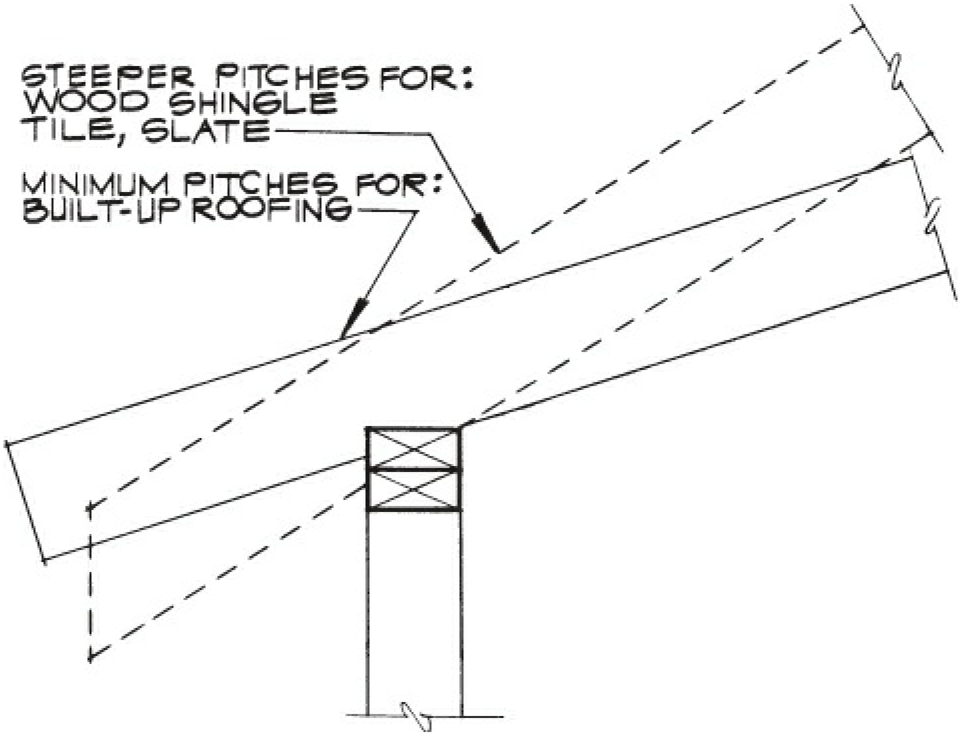


Figure 6.3 Roof material and roof pitches.

SELECTING THE PRIMARY STRUCTURAL SYSTEM

The selection of a structural system and its members is influenced by meeting building code requirements; satisfying design elements; and using the most logical system based on sound engineering principles, economic considerations, simplicity, and environmental factors. For most projects, the architect consults with the structural engineer about systems or methods that will meet these various considerations. A structural concept is required before construction documents can be produced (see Figures 6.4 and 6.5). After a structural concept is established, the decision…making process is based on supporting that concept.

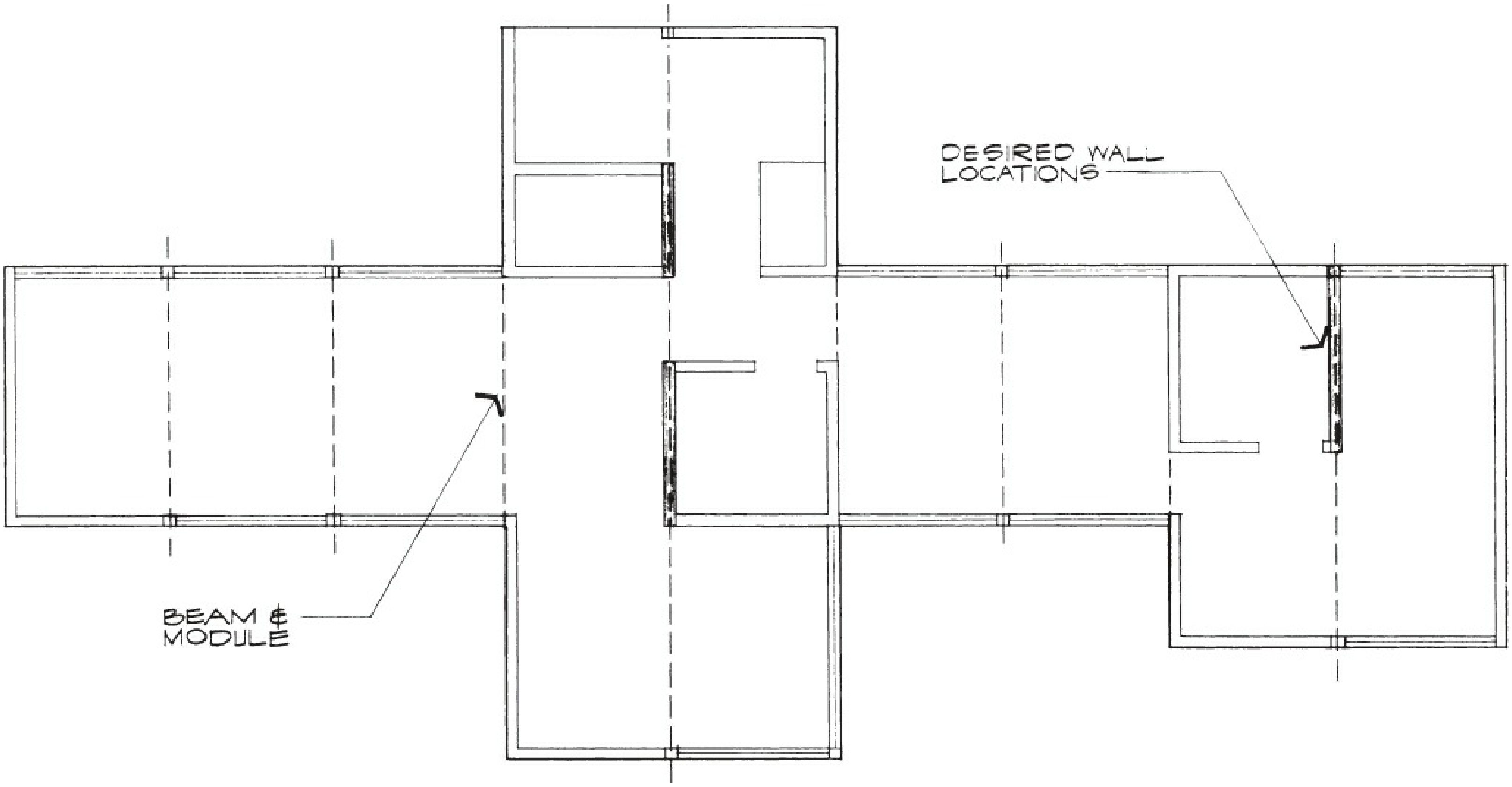


Figure 6.4 Wood post…and…beam structural system.

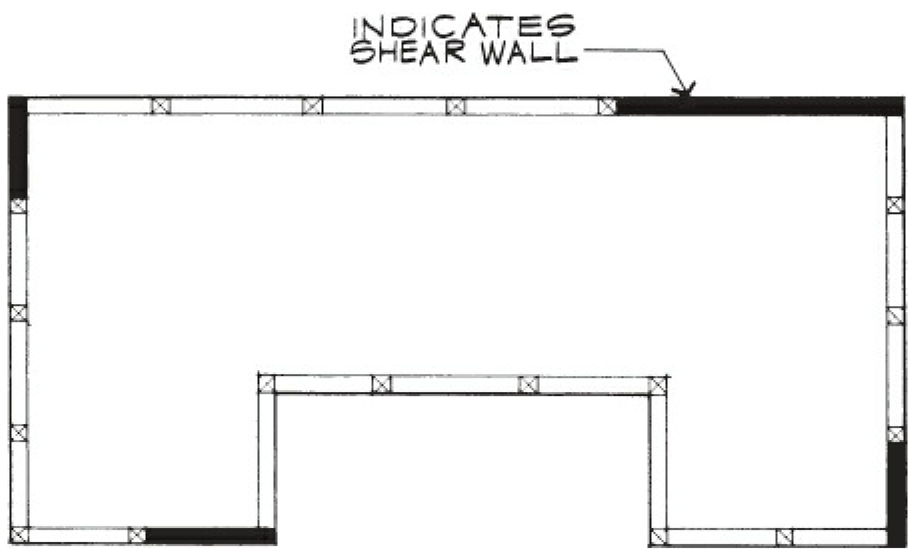


Figure 6.5 Plan view of shear wall locations.

REQUIREMENTS OF CONSULTANTS

Early involvement of structural, electrical, mechanical, and civil engineering consultants is highly recommended. This is especially critical early in the design stage when using BIM. Their early involvement generally results in fewer adjustments having to be made to the finalized preliminary drawings to meet their design requirements. For example, the mechanical engineer's design may require a given area on the roof to provide space for various sizes of roof…mounted mechanical equipment. See Figure 6.6. For projects that require mechanical ducts to be located in floor and ceiling areas, necessary space and clearances for ducts must be provided. Figure 6.7 shows a floor and ceiling section with

provisions for mechanical duct space.

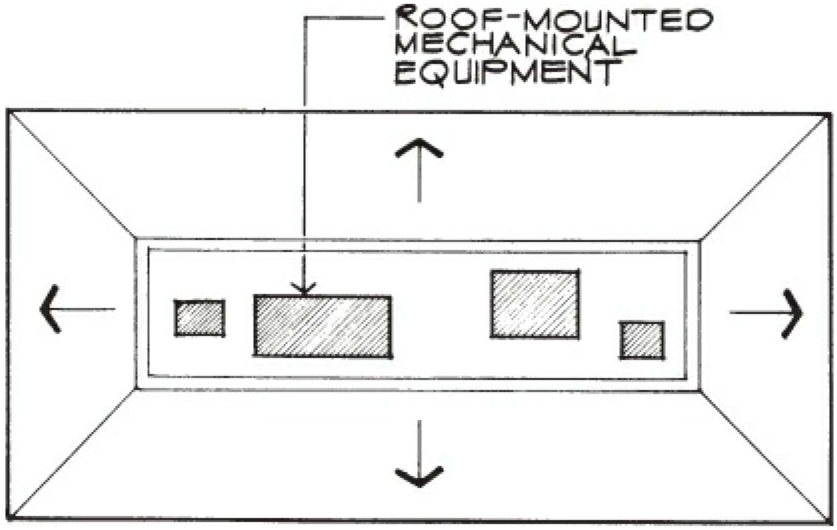


Figure 6.6 Roof plan with mechanical equipment area.

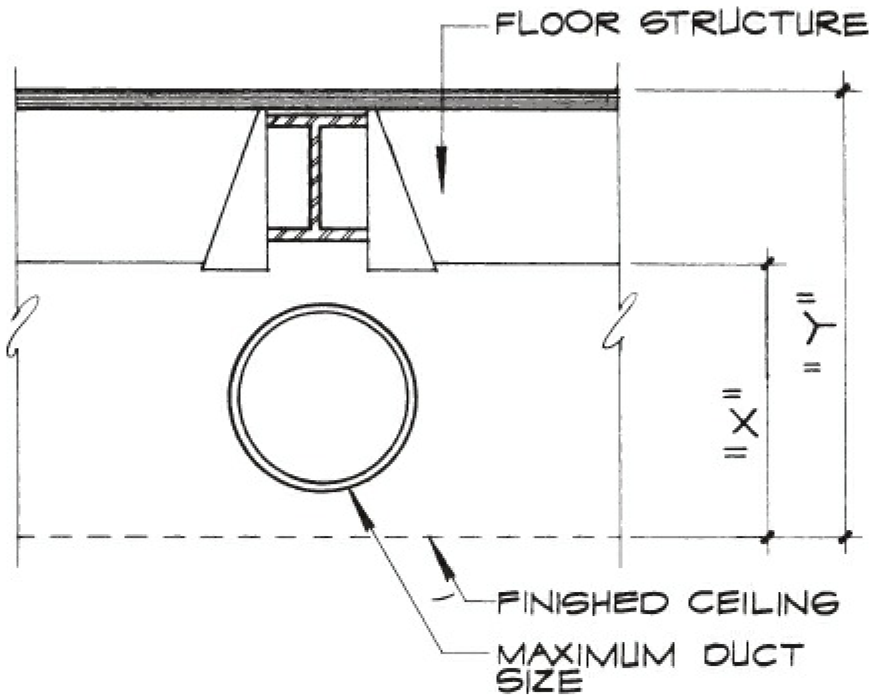


Figure 6.7 Mechanical duct space equipment.

The electrical engineer should also be consulted about any modifications to the building that may be required to provide space for electrical equipment. In most cases, the architect or project manager provides for an electrical equipment room or cabinet in the plans. However, with the increasing sophistication and size of equipment, additional space may be required. This increase in the electrical room dimensions may require a floor…plan adjustment, which can even result in a major or minor plan modification. Figure 6.8 illustrates a floor…plan modification to satisfy space requirements for electrical equipment. Elements such as transformers or backup generators may be required to be placed on the site, so the required clearances must also be accounted for.

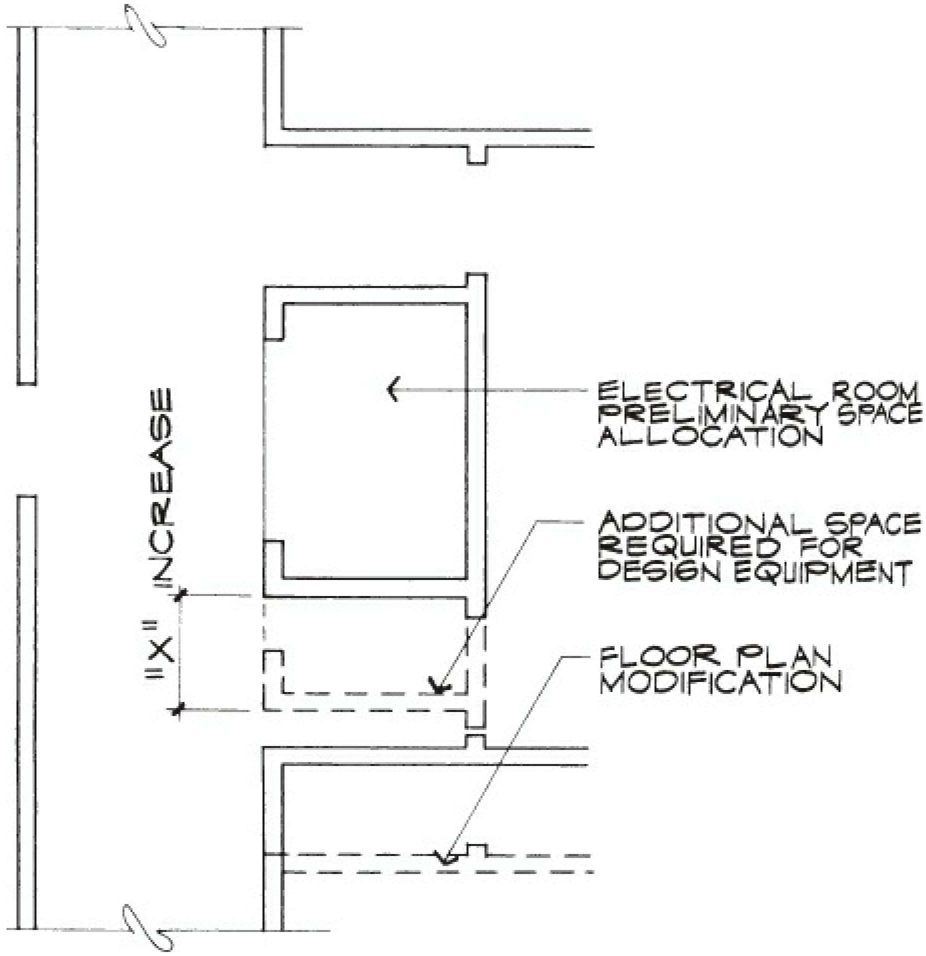


Figure 6.8 Electrical equipment room modification.

REGIONAL CONSIDERATIONS

Regional differences in construction techniques are controlled or influenced primarily by climatic conditions, soil conditions, and natural events and forces such as high winds and seismic activity.

In brief, regional differences influence:

1. Soils or geological requirements
2. Environmental impacts
3. Structural assembly
4. Climatic impacts
5. Material availability

Figure 6.9 illustrates a type of foundation used in regions with cold climatic conditions: an exterior foundation wall and footing with a concrete floor. The depth of the foundation is established from the frost line, and insulation is required under the concrete floor.

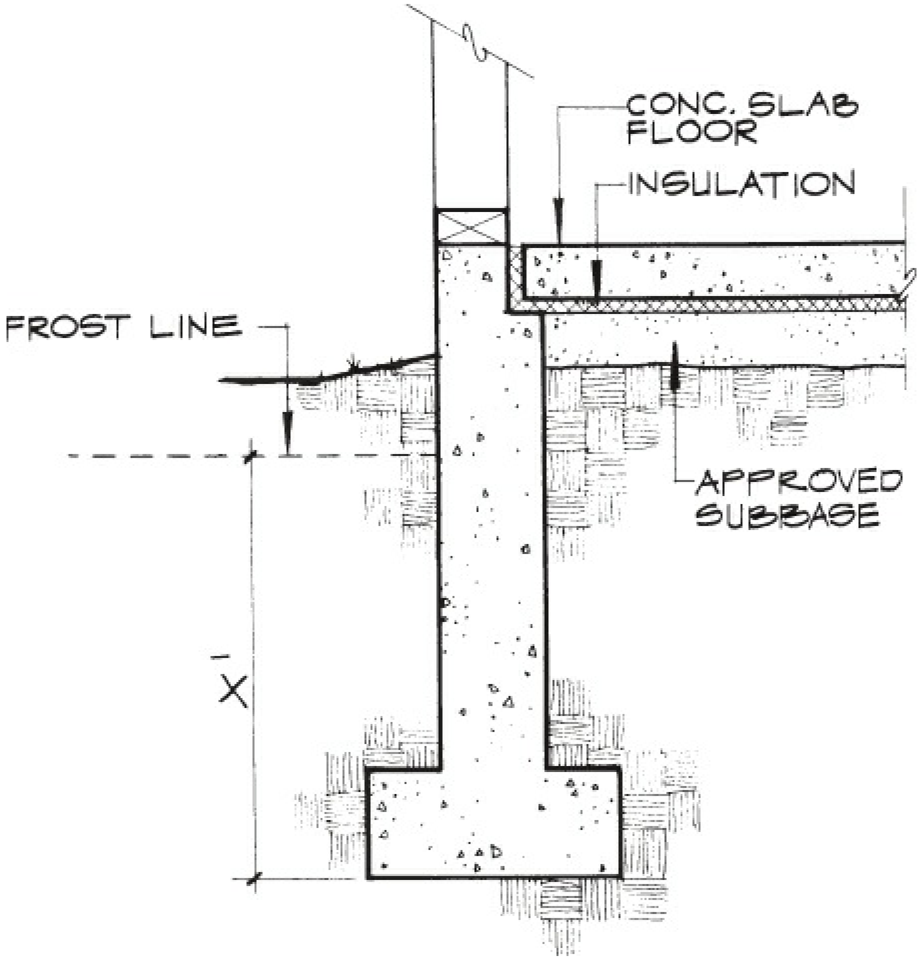


Figure 6.9 Cold…climate foundation conditions.

Where temperatures are mild and warm, the foundation design and construction techniques are primarily governed by soils investigations and local building codes. Figure 6.10 illustrates an exterior foundation detail where the depth of the footing is established to a recommended depth below the natural grade.

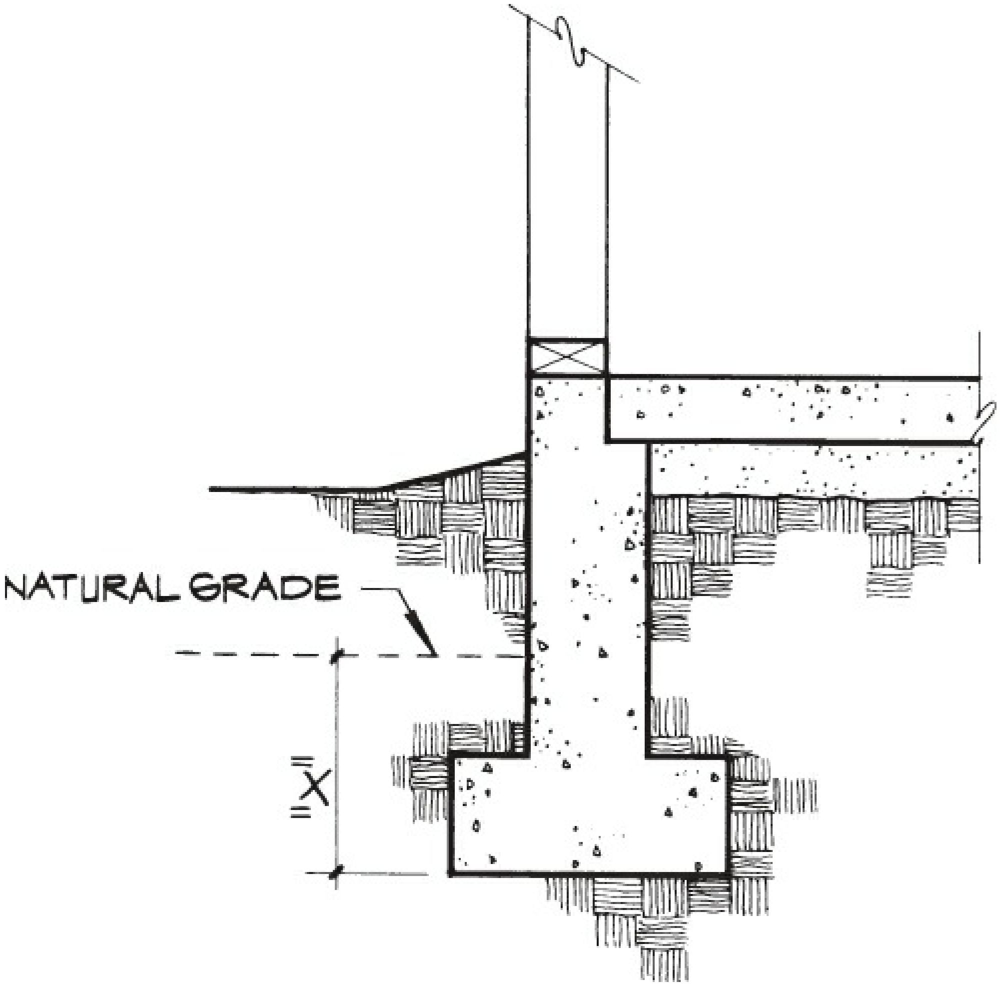


Figure 6.10 Recommended foundation depth in warm climate.

Another example of regional influence is change in exterior wall design. Figure 6.11 shows a section of an exterior wall with wood frame construction. This open‐frame construction is suitable for mild climates. A wood frame exterior wall recommended for eastern regions is shown in Figure 6.12. Here, solid sheathing is used, and this in turn requires the wood studs to be set in from the face of the foundation wall. This one regional difference can affect many procedures and detailing throughout the construction documents, such as wall dimensioning, window details, and door details.

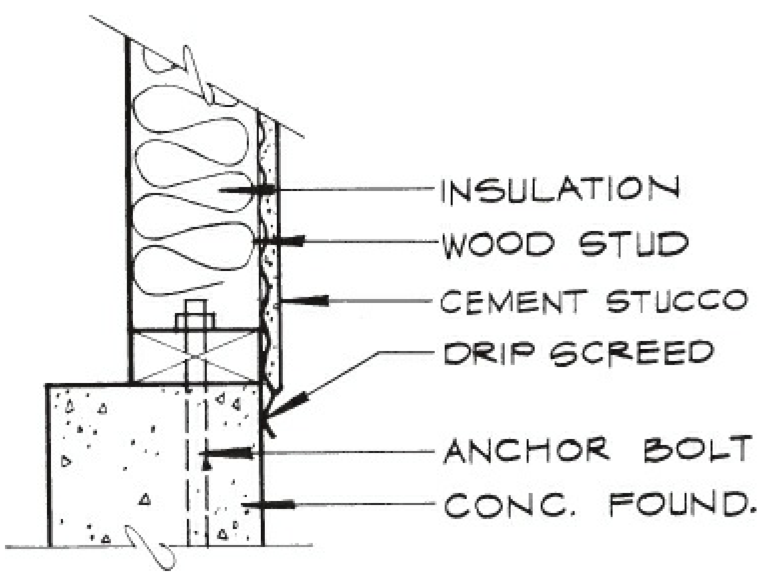


Figure 6.11 Exterior wall: Open‐frame construction.

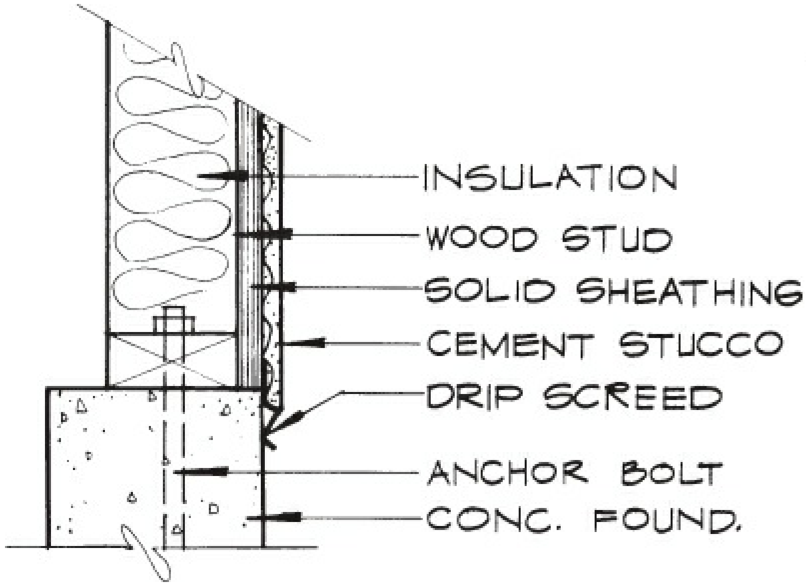


Figure 6.12 Exterior wall: Sheathed frame construction.

Not every material is available in every region. For example, if a specific species of lumber is available only on the East Coast, it may not be environmentally or economically feasible to ship that lumber across the country; hence, these regional considerations would mandate selection of a different timber.

ENERGY CONSERVATION

To determine what you must do to satisfy local and federal energy conservation requirements, you must complete preliminary research. These requirements can affect exterior wall material and thickness, amount and type of glazing, areas of infiltration (leakage of air), amount of artificial lighting to be used, thickness and type of insulation, mechanical engineering design, and so forth. For example, a wood building requires exterior walls to be 2 × 6 studs instead of 2 × 4 to allow for the thickness of the building insulation. This particular requirement dictates procedures in the construction document process, such as floor…plan wall thickness and dimensioning, window and exterior door details, and other related exterior wall details. Figure 6.13 shows a segment of a floor plan that indicates the thickness of walls and the locations of required insulation.

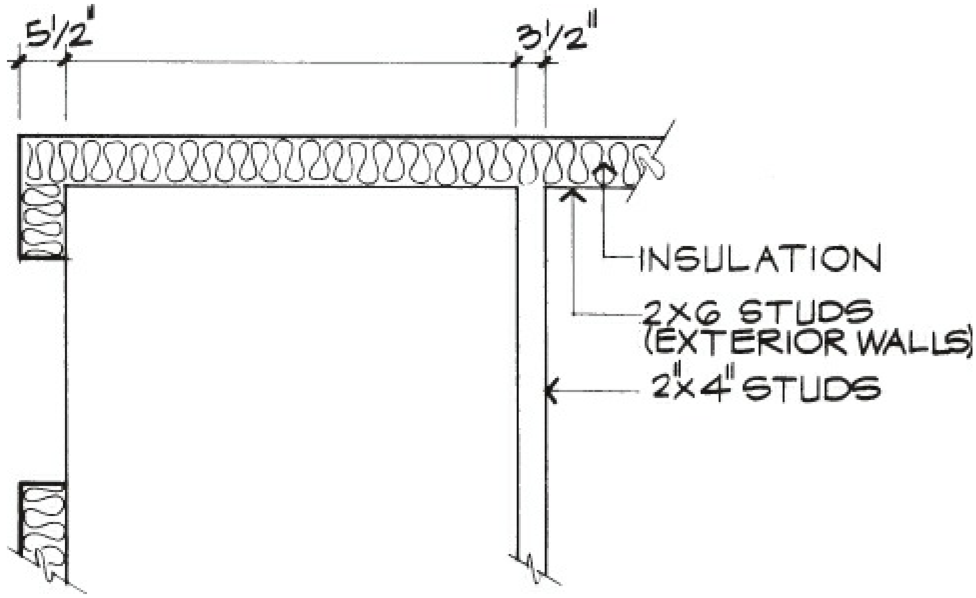


Figure 6.13 Floor‐plan wall thickness.

An excellent example of an award‐winning mechanical system that produces energy savings is an ice bank. The use of storage tanks in the design of a mechanical system can increase operating efficiency and considerably reduce both the electrical costs and the amount of energy used. An example of this storage‐tank approach is the use of ice storage tanks to produce cooling for a large office building. Ice usually forms around the piping that carries the refrigerant located in a tank. The ice is produced during off‐peak hours, such as during the night, when energy costs are at their lowest. This then provides the necessary coolant during the following day's peak‐use hours. See Figure 6.14.

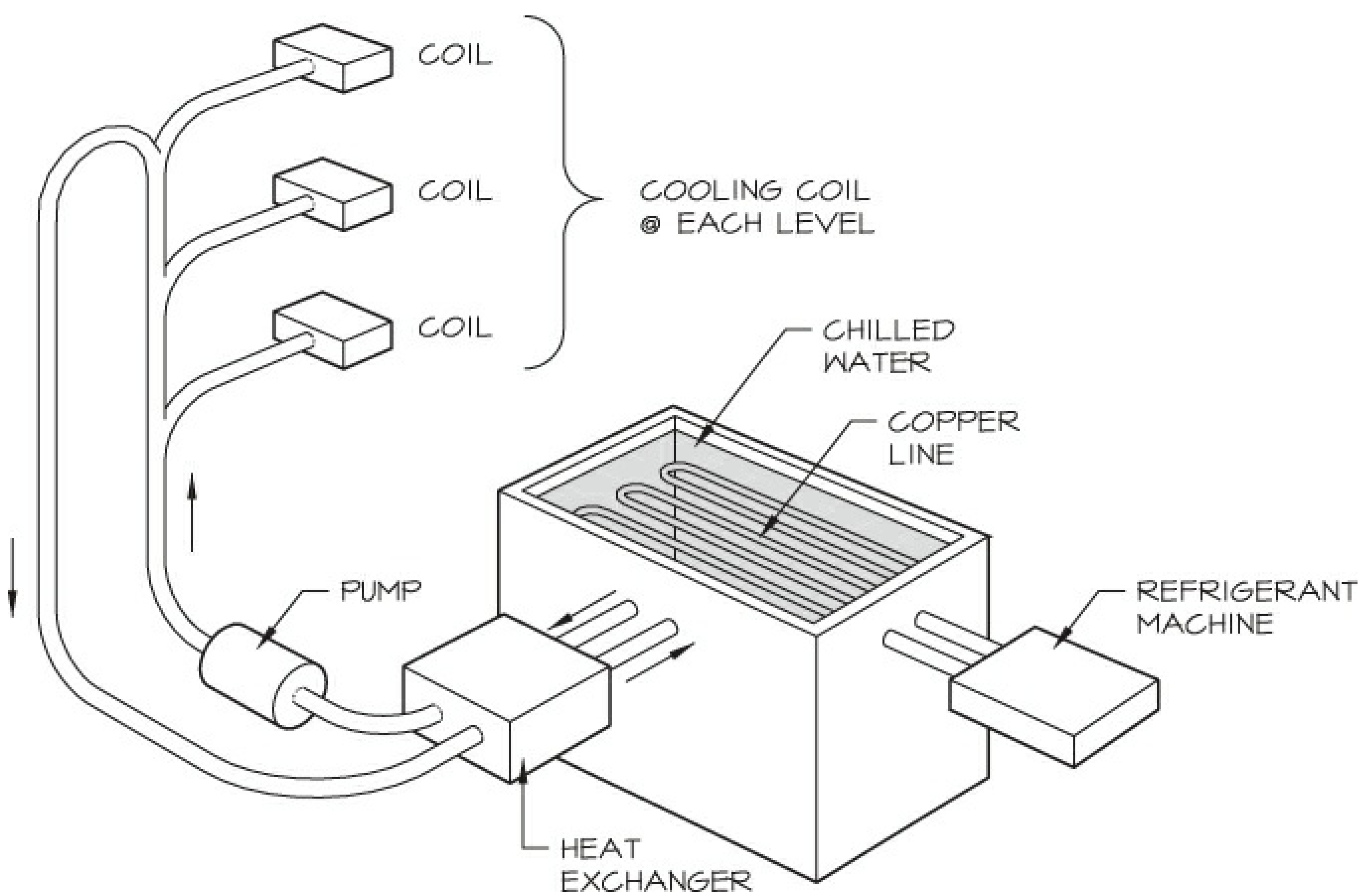


Figure 6.14 Ice bank system.

PROJECT PROGRAMMING

A client provides a list of requirements. In some cases it is very specific, and in others it may be a list of words that evoke an emotion. In either case, it is the role of the architect to design a solution that meets or exceeds the goals set by the client. This list is called the *program*. Every phase of the design process requires the architect to review the program to determine if the design solution is consistent with the program needs and demands. Understand that a program is not static; it can, in fact, be evolving during the various phases of the design process. This process must be reviewed in every phase with the client to ensure that the goals have been met. In many offices, the program is updated as a component of the project book or binder and the various evolutions of the program and memorialized as a study of the project changes.

INTERRELATIONSHIP OF DRAWINGS

When you develop construction documents, you must have consistent relationships between the drawings for continuity and clarity. These relationships vary in their degree of importance.

For example, the relationship between the foundation plan and the floor plan is most important because continuity of dimensioning and location of structural components for both are required. See Figure 6.15. The dimensioning of the floor plan and the foundation plan are identical, and this provides continuity for dimensional accuracy.

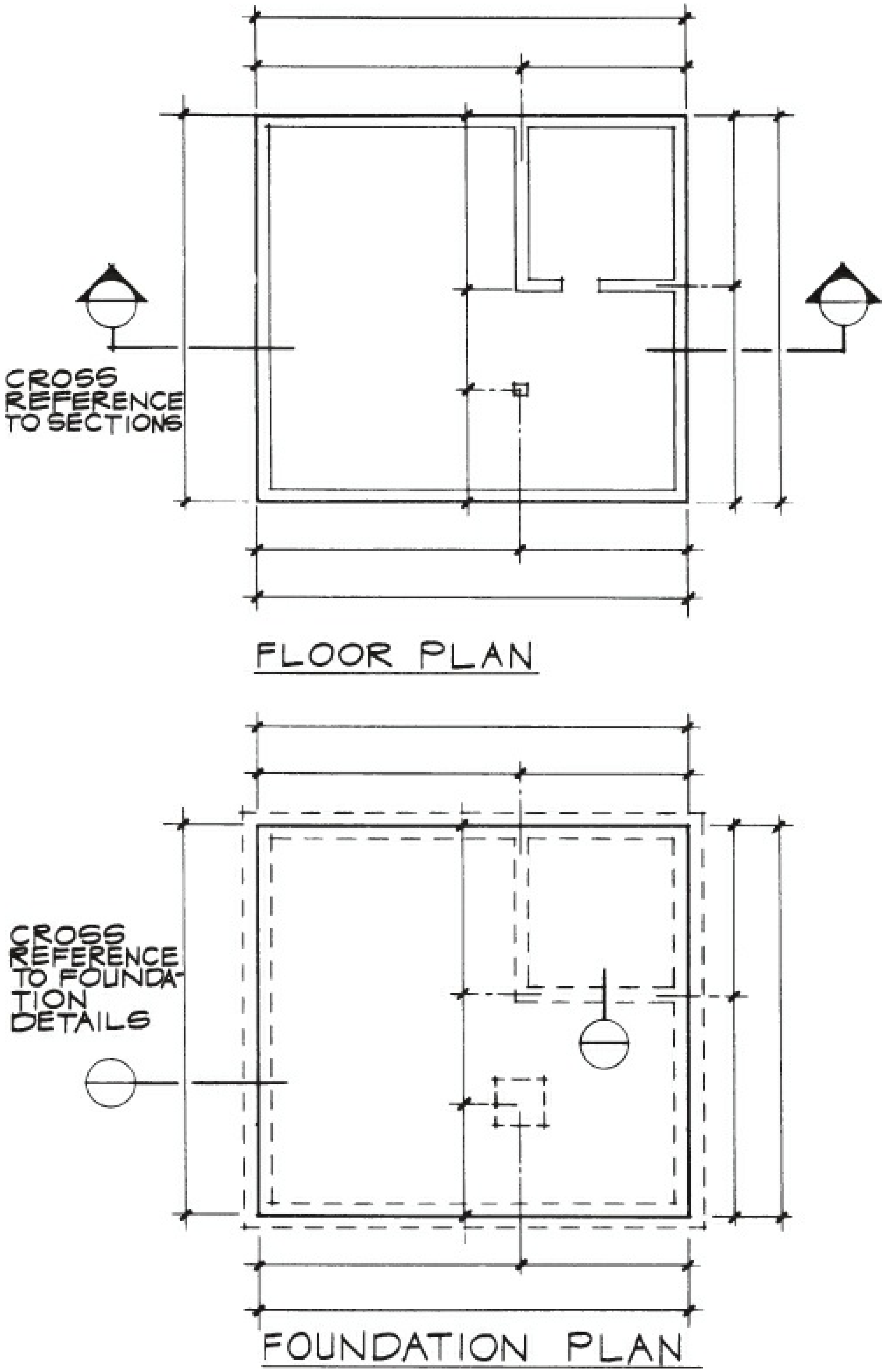


Figure 6.15 Relationship of foundation plan and floor plan.

The relationship between drawings for the electrical plan and the mechanical plan is also critical. The positioning of electrical fixtures must not conflict with the location of mechanical components, such as air supply grilles or fire sprinkler heads.

Cross…reference drawings with important relationships such as these and constantly review them during preparation of the construction documents. The utilization of BIM programs identifies conflicts and aids in determining where revisions are required.

This cross…referencing and review is not as critical with drawings that are not so closely related, such as the electrical plan and the civil engineering plans, or the interior

elevations and the foundation plan. Nevertheless, it can still be important.

Standards and Procedures

Most offices have a set procedure for planning the transition from schematic drawings to the development and execution of construction documents. In a small office, it may be a simple matter of the principal giving verbal directives to employees until a specific system is understood. In a large office, the system may be an intricate network of preplanned procedures.

There are two items in any office with which the beginner will be confronted. These are described herein as **standards**, standard graphic and written patterns to which the office subscribes, and **procedures**, the methods that are instituted during this transition and by which the standards are implemented.

Many offices have a booklet called **Office Standards** or the **Drafting Room Manual**. These are critical to both the employee and the employer. In large architectural firms, employees are asked to study and learn these standards. See Figure 6.16. It contains such items as the following:

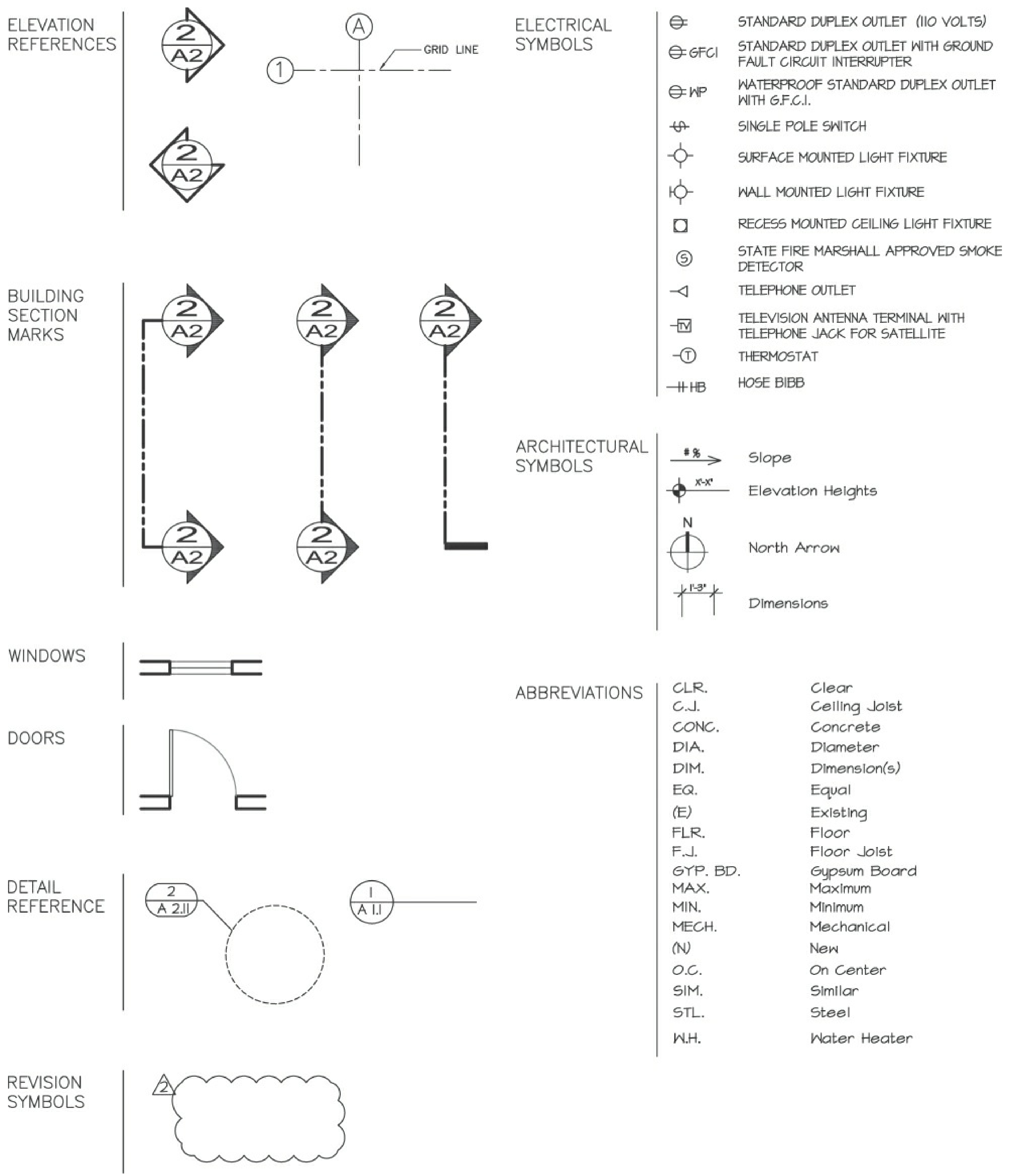


Figure 6.16 Sample of standard conventions.

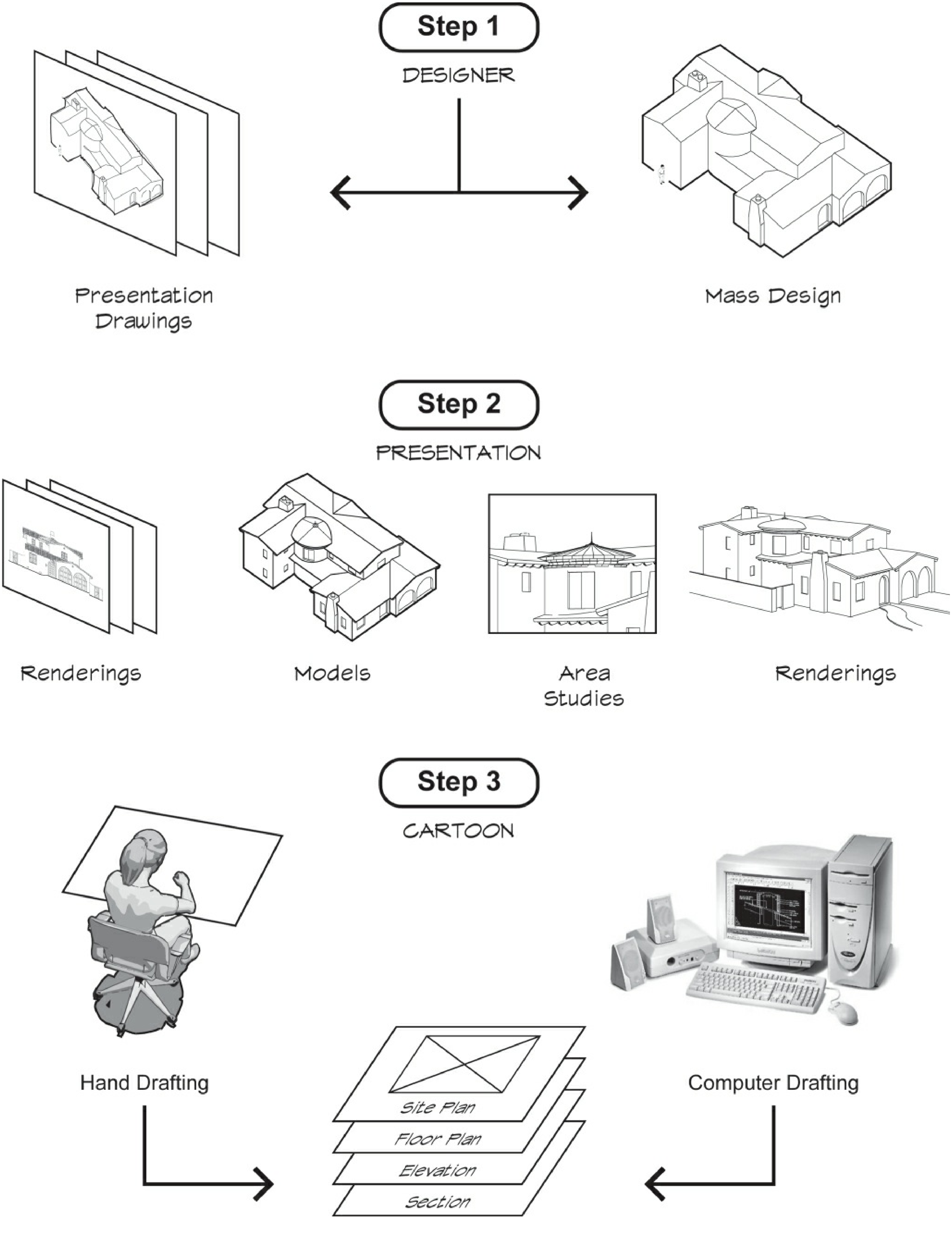
1. A “Uniform List of Abbreviations” for working drawings

2. Material designations in plan, section, and elevation
3. Graphic symbols
4. Methods of representing doors and windows in both plan and elevation
5. Mechanical, electrical, and plumbing symbols
6. Graphic representations of appliances and fixtures
7. Sheet layout and drawing modules
8. Line weights and layers
9. BIM

Working Drawings

One should be able to locate, at a moment's notice, the precise progress of a set of construction documents. This is particularly critical for the office manager or job captain, who must track the progress of a set of drawings for budgetary reasons. He or she must know whether an entire set will meet the deadline, as well as the progress of a single drawing. In this way, the manager can check the productivity of employees, give an extra push to those falling behind, compliment those working ahead of schedule, and even recommend some for raises.

It is important to understand the total sequence followed by drafters so that individual participants can track their progress in relation to their colleagues to ensure that all drawings produced by the team will progress equally. For an overview of where areas of participation fit into the whole scheme of things in an office, see Figure 6.17. The initial design phase is done either by hand or by computer.


Step 1
DESIGNER
Presentation Drawings
Mass Design
Step 2
PRESENTATION
Renderings
Models
Area Studies
Renderings
Step 3
CARTOON
Hand Drafting
Computer Drafting
Site Plan
Floor Plan
Elevation
Section

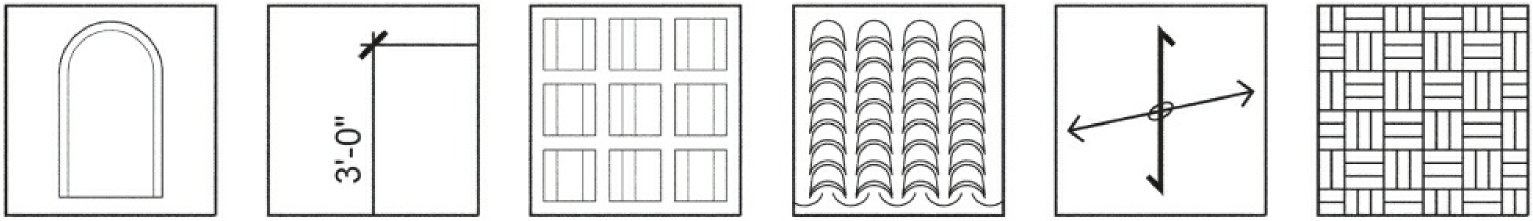
Step 4

Hand Drafting

UPDATE DRAWINGS

Computer Drafting

Openings, Dimensioning, Doors/Windows, Roof Shapes, Floor Framing, Selected Materials



Step 5

CONSULTANTS & PRELIMINARIES

Associates				Municipalities	
Civil	Electrical	Mechanical	Structural	City	Other

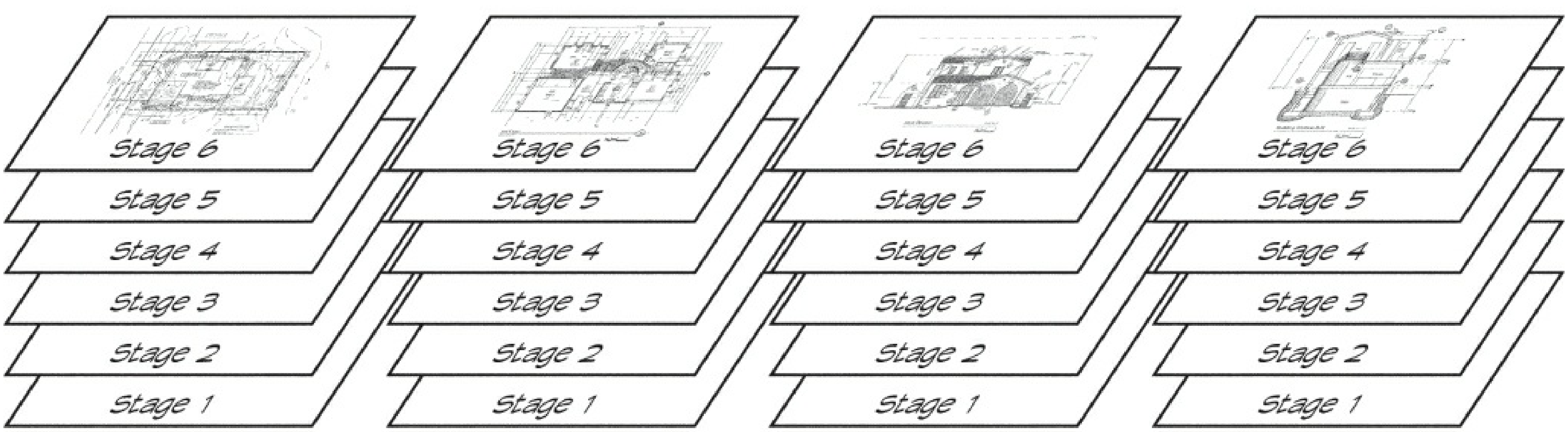
Step 6

Hand Drafting
(See Chapter 2)

CONSTRUCTION DOCUMENTS

Computer Drafting
(See Chapter 3)

Six-Stage Development



Site Plan

Floor Plan

Elevation

Section

Figure 6.17 From design to working drawings.

Datum Base

The first layer of a computer…aided drafting (CAD) drawing should be a datum layer.

The datum is usually based on the material to be used in the construction and the system best suited for that selected material. For example, if steel is selected as the material for constructing a structure, then a matrix system such as the dimensional reference system would be chosen, as it is best suited for constructing with steel. This could be represented by a 25′ × 30′ grid layout that established the location of an ideal structural post location.

For ceilings and floors, neutral zones are used to control the space in between; these are referred to as the *control zones* or *control dimensions*. Thus, the entire dimensioning process is dictated by this matrix datum, even to the drafting of details, which also should be datum based. See Figure 6.18.

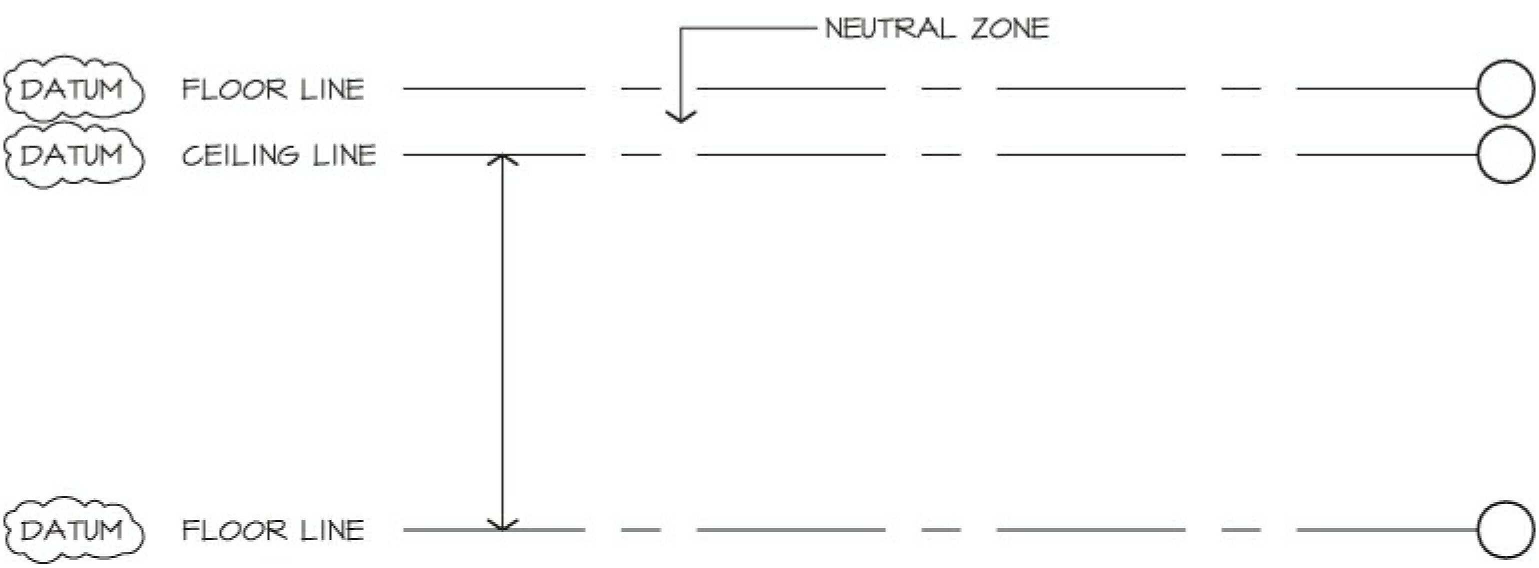


Figure 6.18 Vertical datum layout.

Designing Working Drawings Both Manually and on a Computer

During the design phase, models, renderings, presentational floor and roof plans, elevations, and sections are developed. These are altered or changed after being viewed by the client. Subsequent to this stage, the drafter must realize that design changes cannot be made without the approval of the designer (in conjunction with the client).

The drafter then builds up each drawing through the developmental stages, following basic office standards. The specific stages for the plans, elevations, building sections, and details are covered later in this chapter.

If the design phase includes a computer 3…D model, the drafter's task is simple. The 3…D model is rotated into an orthographic position to obtain plan, elevation, and building sections. The floor plan, which is a horizontal section, is then used as a datum base for other drawings, such as the framing plan, mechanical plan, electrical plan, or plan of any other consultant you might enlist to aid you in the completion of this set of working

drawings. The various stages now become layers, and any combination of layers can be sent to the associates. In fact, these layers in progress can be placed on a web site and downloaded with a specific code given only to the associates.

Formatting

During the planning phase of developing working drawings, someone in the office may be responsible for the layout of the individual document sheets. The planning phase is most affectionately called the **cartooning** of a set of working drawings. **Mock_up**, **page format**, and **sheet layout** are other terms, used interchangeably, for the same thing.

Although the cartooning of a set of drawings can be done at full size, a more expedient method is to draw it at a reduced sheet size, 8½″ × 11″ being the most convenient. This can be performed manually or by CAD. In either case, determining the scale at which a floor plan will be drafted is the biggest problem. See Figure 6.19. As CAD or BIM programs become more sophisticated, the sheet templates are becoming established, but they do allow for customization.

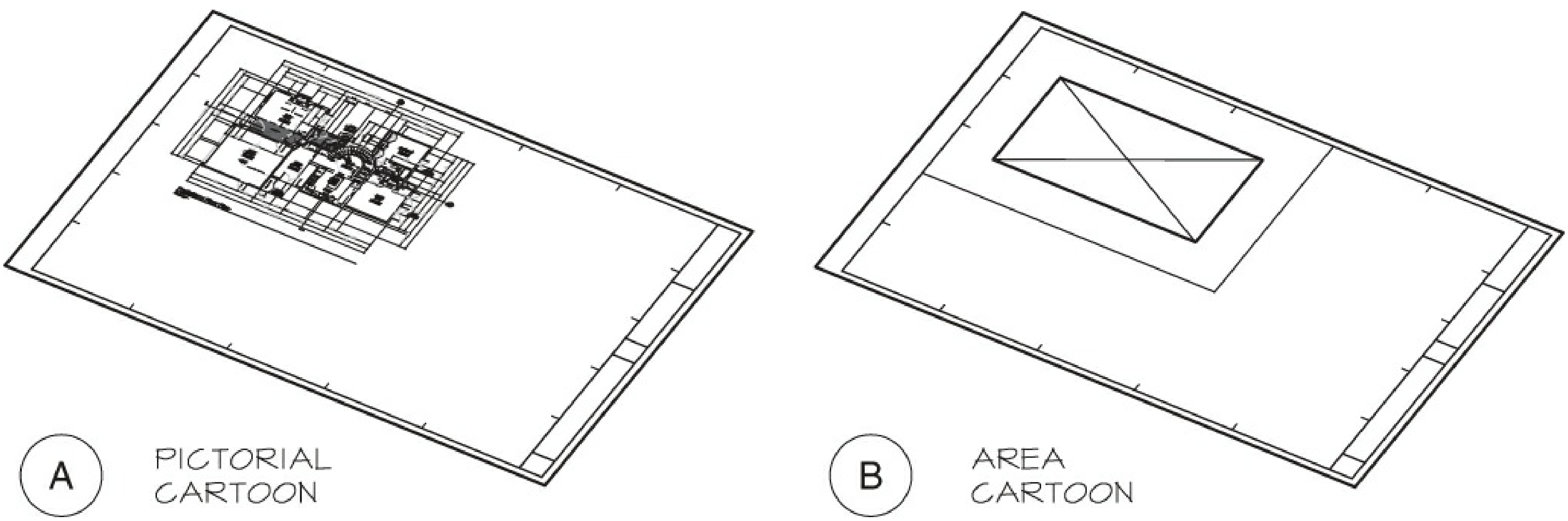


Figure 6.19 Pictorial and area cartoon.

When hand drafting (manually drafting) a cartoon, everything is based on proportion. See Figure 6.20.

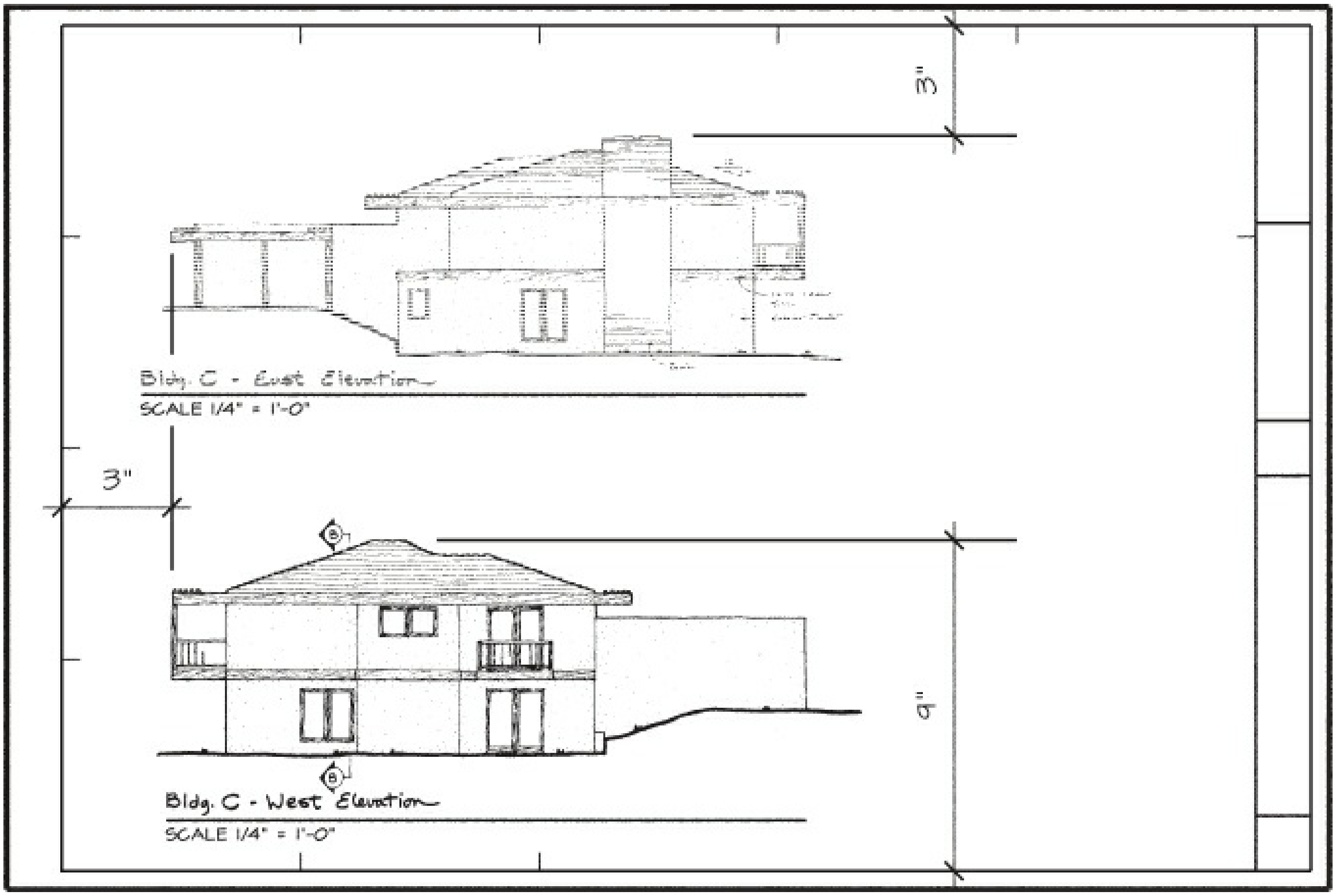


Figure 6.20 Cartoon of the exterior elevation sheet with measurements for positioning the elevations.

Computer cartoons are much easier to produce than hand‐drafted cartoons. The paper is drawn at full scale in model space, and the drawings are imported into the theoretically full‐size sheet in the desired scale to fit. If the plans, elevations, and sections are drawn full scale, the scaling factor is used to create an image in the proper scale. See Figure 6.21.

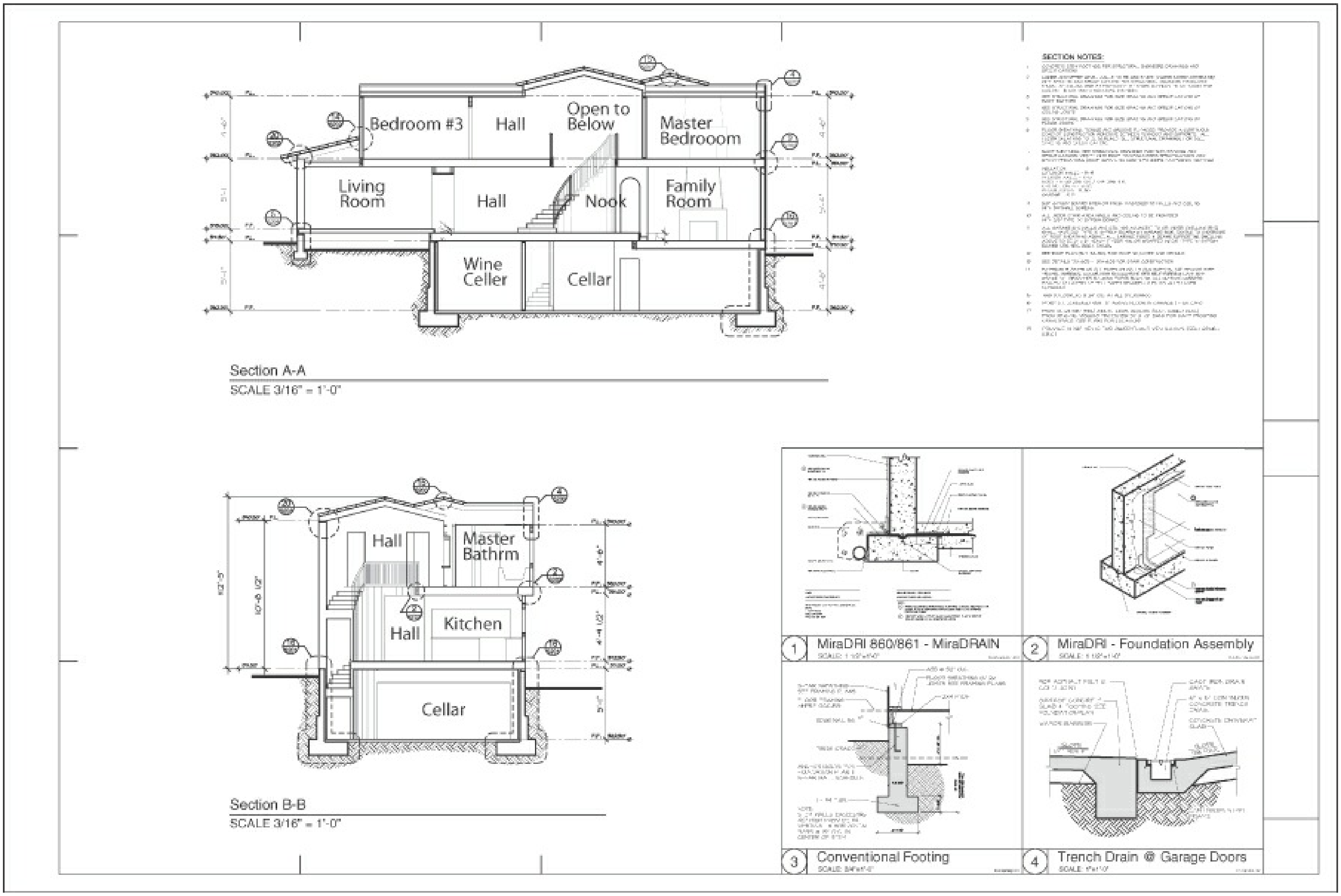


Figure 6.21 Cartoon of building section and details.

If drawings are not available, as is usually the case with interior elevations, rectangles can be drawn at the desired scale to occupy the space allocated for a cartoon. See Figure 6.22.

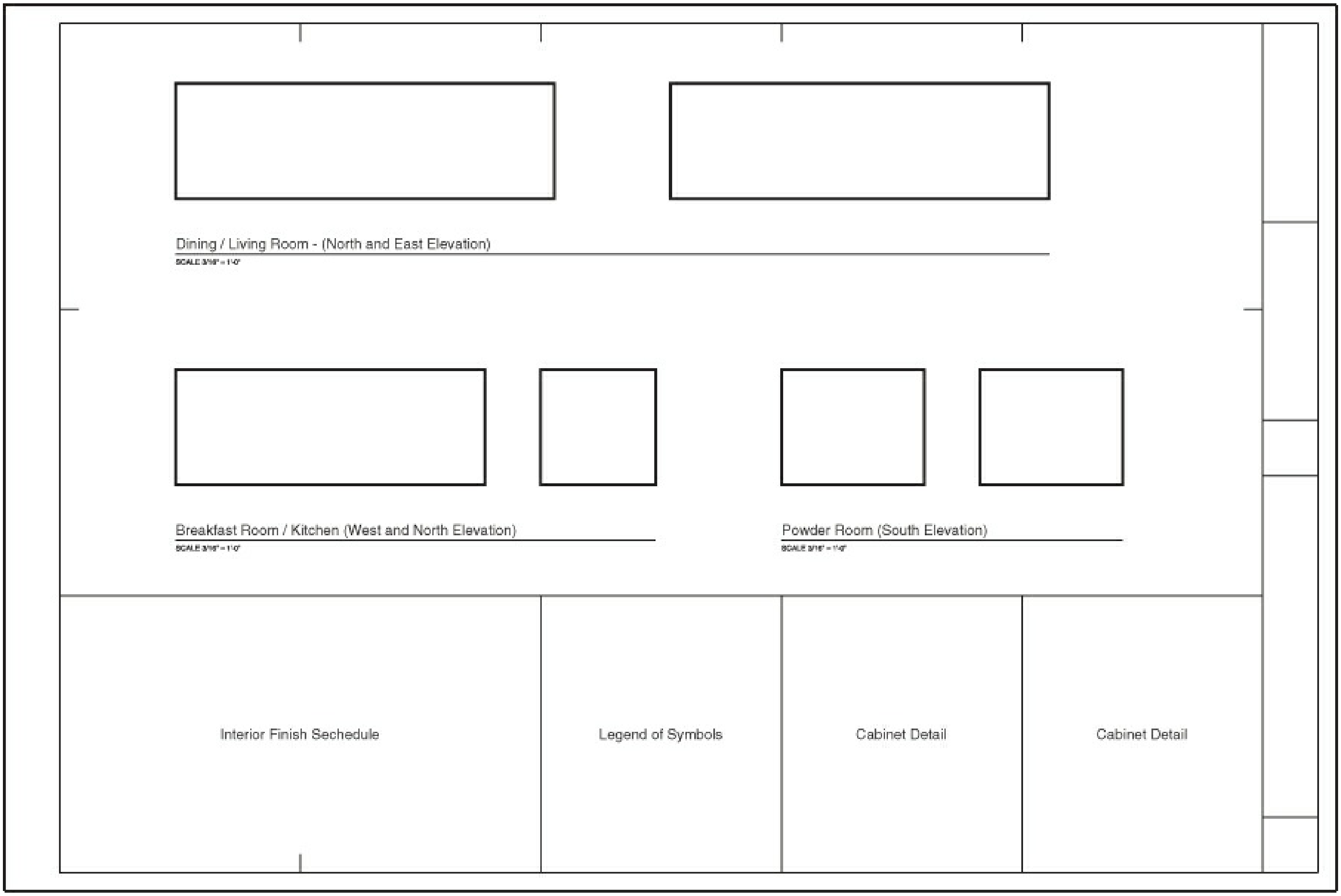


Figure 6.22 Cartoon using rectangles to reserve space.

PROJECT BOOK

Project Materials and Specifications

All information about a specific project—the materials selected, the structural system chosen, the exterior finishes and interior finishes, plus all correspondence relating to the project—is documented, collected, and placed in a **project book**. This can be a simple three…ring binder or a series of binders. Lists of structural considerations, exterior finishes, and interior finishes are shown in Figures 6.23, 6.24, and 6.25, respectively.

STRUCTURAL

1. FOUNDATION	2. TYPICAL WALL FRAMING	3. TYPICAL FLOOR FRAMING	4. TYPICAL ROOF FRAMING
a. Conventional slab-on-grade	a. 2 x ___ wood studs	a. 2 x wood floor joists	a. Conventional (wood rafters & beams)
b. Post-tensioned slab	b. Lap with corner boards	b. 2 x wood floor joists per structural consultant	b. TJI
c. Wood floor	c. Other	c. TJI	c. Trusses
d. Other		d. 1-1/2" lightweight concrete over	d. Trusses and conventional framing
		e. Other	
		Note: Specify any minimum sizes	Note: Specify any minimum sizes

Figure 6.23 Listing of structural considerations.

EXTERIOR FINISHES

A. WALLS			
1. STUCCO	2. CEDAR SIDING	3. MASONITE SIDING	4. MASONRY VENEER
a. Sand texture	a. Lap with mitered corners	(specify other manufacturers)	a. Thin set brick (mfg.)
b. Other	b. Lap with corner boards		
		a. Lap with metal corners	b. Full brick (mfg.)
		b. Lap with corner boards	c. Stone
		c. V-groove with corner boards	d. Stucco stone
		d. Other	e. Other

B. TRIMS, BARGES, AND FASCIA	
1. SIZE	2. TEXTURE
a. X ___ Trim at windows and doors	a. S4S
___ Whole house	b. Resawn
___ Front elevation only	c. Rough sawn
b. X ___ Barge and fascia with ____ X ____Trim over	d. Other

C. ROOFING			
1. MATERIAL	2. GUTTERS	3. DIVERTERS AT DOORS	
a. Wood shakes	a. At whole house	Composition shingle	Only
b. Wood shingle	b. At doors only	Wood shake and shingle	
c. Concrete "s" tile (mfg.)		Flat concrete tile	
d. Clay "s" tile (mfg.)	*Note:* Gutters will be assumed at all tight eave conditions.		
e. Clay 2-piece mission tile (mfg.)			
f. Flat concrete tile (mfg.)			
g. Composition shingle (mfg.)			
h. Built-up			
i. Built-up with gravel surface			
j. Other (mfg.)			

D. DECKS AND BALCONIES	E. STAIRS	
1. TYPE	1. THREADS	2. STRINGERS
a. 2 X spaced decking	a. Open wood treads	a. Steel stringers
b. Dex-o-Tex waterproof membrane decking	b. Precast concrete threads	b. Wood stringers
c. Other	c. Conc.-filled metal pan treads	
	d. Dex-o-Tex waterprf. membrane	

F. DOORS	
1. ENTRY	3. PATIO / DECK
a. 3068 1-3/4" S.C. (mfg.)	a. Aluminum sliding glass door
b. 3080 1-3/4" S.C. (mfg.)	b. Aluminum French doors
c. Other	c. Wood sliding glass door
2. GARAGE	d. Wood French doors
a. Overhead	e. Other
b. Wood roll-up (mfg.)	
c. Metal roll-up (mfg.)	

G. WINDOWS		
1. Aluminum	Wood	2. MUNTINS
a. Sliding		a. All windows
b. Single-hung		b. Front elevation and related rooms
c. Double-hung		3. Dual glazed
d. Awning		4. Single and dual glazing per Title 24
e. Casement		5. Other

H. SKYLIGHTS			
1. GLASS (mfg.)	2. ACRYLIC (mfg.)		3. GLAZING
Color	Color	Shape	a. Single
a. Bronze	a. Bronze	a. Flat	b. Double
b. Gray	b. Gray	b. Dome	c. Per Title 24 report
c. Clear	c. Clear	c. Pyramid	d. Other
d. White	d. White	d. Other	
e. Other	e. Other		

Figure 6.24 Listing of exterior finishes.

INTERIOR FINISHES

A. WALLS

	1. Drywall - Texture
	2. Plaster - Texture
	3. Other
	4. Bullnose Corners

B. FLOORS

		Carpet	Sheet Vinyl	Ceramic Tile	Other
	Entry				
	Living				
	Dining				
	Family				
	Den				
	Kitchen				
	Nook				
	Hall				
	Master Bedroom				
	Second Bedroom				
	Master Dressing Room				
	Second Bathroom				
	Powder				
	Service				

C. CEILING

	1. Drywall - Texture	
	2. Plaster - Texture	
	3. All dropped beams shall be drywall wrapped	
	4. All dropped beams shall be exposed	
	5. Other	

D. CABINET TOP AND SPLASH

		Ceramic Tile	Corian	Cult. Marb	Cult. Onyx	Plastic Lam.	Wood	Other	Splash Hght.
	Kitchen								
	Service								
	Wet Bar								
	Powder								
	Linen								
	Master Bathroom								
	Second Bathroom								

E. INTERIOR DOORS

	1. Passage		2. Wardrobe	
	Master Bedroom		a. 6'-8" high siding	
	a. 3068		b. 8'-0" high siding	
	b. 2868		c. 6-'8" high bifold	
	c. Other		d. 8'-0" high bifold	
	Secondary Bedrooms		e. Other	
	a. 2868			
	b. 2668			
	c. Other			
	3. Mirrored			
	a. Master Bedroom			
	b. Secondary Bedroom			
	c. Other			

F. BATHROOM FIXTURES

		Master Bath	Second Bath
	1. Tubs and Tub/Showers		
	a. 3'-6"x5'-0" cast iron oval tub		
	b. 3'-6"x5'-0" porc/stl. oval tub		
	c. 3'-6"x5'-0" fiberglass oval tub		
	d. 3'-6"x5'-0" 1-piece fiberglass oval tub and surr.		
	e. 2'-8"x5'-0" cast iron tub		
	f. 2'-8"x5'-0" porc./stl. tub		
	g. 2'-8"x5'-0" 1-piece fiberglass oval tub and surr.		
	h. Other		
	Note : Specify surrounding material		
	2. Showers		
	a. Fiberglass pan and surround		
	b. Hot mopped ceramic tile pan with ceramic tile surrounding material		
	c. Precast pan with surround		
	Specify: Type Pan		
	Type Surround		
	d. Shatterproof enclosure		
	e. Curtain rod		
	3. Mirrors		
	a. 3'-0" high		
	b. 3'-6" high		
	c. 3'-8" high		
	d. 4'-0" high		
	e. Full height to ceiling		
	4. Medicine Cabinets		

G. KITCHEN APPLIANCES

	1. Sink
	a. Double
	b. Double with garbage disposal
	c. Triple
	d. Triple with garbage disposal
	2. Built-In Oven
	a. Double - gas
	b. Double - electric
	c. Single with microwave
	3. Built-in Cooktop
	a. Gas
	b. Electric
	c. Downdraft - gas
	d. Downdraft - electric
	e. Hood, light and fan above
	f. Microwave above
	4. Slide-in Range/Oven (30")
	a. Gas
	b. Electric
	c. Downdraft - gas
	d. Downdraft - electric
	e. Hood, light and fan above
	f. Microwave above

	G. KITCHEN APPLIANCES (continued)
	5. Hi/Low Slide-in Range/Oven (30")
	a. Gas
	b. Electric
	c. Oven below and above
	d. Oven below, microwave above
	6. Dishwasher
	a. Included
	7. Trash Compactor
	a. Included
	Size
	8. Refrigerator
	a. 3'-3" wide space
	b. 3'-0" wide space
	c. Other
	d. Stub-out for ice maker
	e. Recessed stub-out for ice maker
H. LAUNDRY	
	1. Dryer
	a. Gas
	b. Electric 220V
	c. Both
I. MECHANICAL	
	1. F.A.U.
	a. Gas
	b. Electric
	c. Zoned - Specify number of units __________
	1. Air Conditioner
	a. Included
	b. Optional
J. PLUMBING	
	1. Water Heater - Gas
	a. Recirculating
	b. Water softener - included
	c. Water softener - loop only
	2. Exterior Hose Bibb
	a. Total Required ______________________________
	b. Locations: ______________________________

	K. ELECTRICAL	Surface Mounted	Rec. Can Light	Square Flush Light	Lum. Clg. (Fluor.)	Lum. Soffit (Fluor.)	Lum. Soffit (Incand.)	Wall Mounted	Pendant	Other
	1. Location									
	Entry									
	Living									
	Dining									
	Family									
	Den									
	Kitchen									
	Nook									
	Stair									
	Hall									
	Master Bedroom									
	Second Bedroom									
	Master Dress									
	Second Dress									
	Master Bath									
	Second Bath									
	Powder									
	Service									
	2. Outlet for Garage Door Opener									
	3. Exterior W.P. Outlets									
	a. Total Required:____________________________									
	b. Location: ____________________________									
	4. Phone Outlets - Locations									
	a. ____									
	b. ____									
	5. TV Outlets - Locations									
	a. ____									
	b. ____									
	6. Intercom System									
	a. Wired									
	b. Option									
	7. Security System									
	a. Wired									
	b. Option									

	L. FIREPLACES
	1. Prefab Metal
	a. Manufacturer
	b. Size
	c. Gas stub-out
	2. Precast Concrete
	a. Manufacturer
	b. Size
	c. Gas stub-out
	3. Masonry Sizes
	b. Size
	c. Gas stub-out

	M. Miscellaneous Amenities
	1. Safe
	a. Wall - location ____________________________
	b. Floor - location ____________________________
	2. Wet Bar - Plans
	Under-counter
	Ice maker ______________________________
	Refrigerator,___________________________
	3. Other (specify)
	a.
	b.

Figure 6.25 Listing of interior finishes.

Exterior and Interior Finishes

In the development of the exterior elevation, the drafter must be able to identify the various materials to be used on the exterior surface, as well as the type of fenestration (windows and doors). As with structural considerations, a chart is again the instrument used to convey the information to the drafter. See Figure 6.24.

To allow an accurate drawing of the floor plan, interior elevation, and finish schedule,

interior finishes are selected by the client, in conjunction with the architect. The drafter can find this information in the project book on a chart similar to the one shown in Figure 6.25. Although this list is called "Interior Finishes," it can include appliances and other amenities such as fireplaces, a security system, a safe, and so on.

Legal Description

Every project has some type of legal description. A simple description might look like this:

Lot #_______________ Block #_________________

Tract #____ , as recorded in book ____ , page ____ , of the _________________ County recorder's office.

This description must appear on the set of working drawings. It may be on the title sheet or on the site plan or survey sheet.

The legal description is used when researching your client's site: zoning requirements and limitations, setback requirements, height limits, or any other information you might need for a specific design feature of the project.

Job Number

Every office has its own way of identifying a specific project. Generally, each project is assigned a job number, which might incorporate the year of the project, the month a job was started, or even the order in which the project was contracted. For example, job number 1503 might reflect the third project received in an office in the year 2015. By using this system, an office can rapidly identify the precise year in which a job was contracted and never duplicate a number.

Task Number

All offices use time sheets, applications, or log data into a time spreadsheet; the data include keeping track of the drafter's performance. A drafter might log the time spent on a project by date, the job number, a written description of the task performed, and amount of time, such as:

07–30–15 Job #1503—Tylin Residence—Plans—SD 2.25 hrs.

In a large office, each task is also numbered. Figure 6.26 displays a chart describing the work to be performed as "work packages"; the task number at the left is assigned to the specific package, and a column at the right indicates the total man…hours planned for the particular work package. The task numbers jump by 10, allowing the flexibility, on a complex project, to have sub…work packages. For example, 140 Site Visit might use 141 as a task number for measuring an existing structure to be altered.

ADDITIONAL SERVICE CHECKLIST
SINGLE-FAMILY SUMMARY OF PLANNED MAN-HOURS

PROJECT NAME: ____________________
PROJECT NO: ____________________
PROJECT MANAGER: ____________________
START DATE ____________________

	WORK PACKAGE NAMES	PLANNED MAN-HOURS
110	BUILDING DEPARTMENT PLAN CHECK	
120	BUILDING DEPARTMENT SUBMITTAL	
130	IN-HOUSE PLAN CHECK	
140	SITE VISIT	
150	PRODUCTION ASSISTANT/PRINTING	
160	CONSTRUCTION DOCUMENTS (DIR. & ASSOC DIR.)	
170	FOUNDATION LAYOUT (ARCHITECTURAL)	
180	FLOOR PLAN	
190	ARCHITECTURAL BACKGROUND	
200	EXTERIOR ELEVATIONS	
210	BUILDING SECTIONS	
220	DETAILS	
230	INTERIOR ELEVATIONS	
240	ROOF PLAN	
250	STAIRS PLANS	
260	NOT USED	
270	NOT USED	
280	FOUNDATION PLAN (STRUCTURAL INFORMATION)	
290	FRAMING PLAN (STRUCTURAL)	
300	TITLE SHEET	
310	SITE PLAN	
320	SCHEDULES	
330	PLAN CHANGE (SINGLE FAMILY)	
340	PROJECT MANAGEMENT (PROJECT MGR./ARCHITECT)	
350	PROJECT MEETINGS (TEAM MEMBERS)	
360	CAD COORDINATION (DIR. OF CAD SERVICES)	
370	CAN BE USED FOR ADDITIONAL WORK	
380	CAN BE USED FOR ADDITIONAL WORK	
390	CAN BE USED FOR ADDITIONAL WORK	
	TOTAL PLANNED MAN-HOURS	

APPROVED BY:____________________

Figure 6.26 Task numbers and summary of planned man…hours.

Figure 6.27 is an example of the total man…hours for a residence. Note the task numbers and the computer display of the corresponding work…package names.

Summary of Planned Man-Hours		
Project Name: The Professional Practice of Architectural Drawings Case Study—Mr. and Mrs. ____________________ Residence		
Task No.	Work Package Names	Planned Man-Hours
310	Site Plan Roof Plan, and Energy Notes	10
170	Foundation Plan and Details	20
180	Floor Plan and Electrical Plan	20
220/320	Door Window Details and Schedules	32
200	Exterior Elevations and Details	20
210	Building Sections	10
290	Roof Framing Details	20
230	Interior Elevations	16
130	Project Coordination and Plan Check	18
	Total Hours	166
	166 hours $________ Hr. =	$___________

Figure 6.27 Planned man…hours for a project.

As the drafters turn in their time sheets, the project manager must ascertain the progress on a particular job or check to see if the project has been budgeted correctly. Figure 6.28 provides an example of such a spot check.

Summary of Man-Hours Through 12-15-10		
310	Site Plan	2 hrs. 40 min.
310	Vicinity Map	20 min.
310	Roof Plan	1 hr. 15 min.
170	Foundation Plan	3 hrs. 15 min.
320	Foundation details	3 hrs. 55 min.
180	Floor Plan	4 hrs. 5 min.
200	Exterior Elevations	3 hrs. 55 min.
210	Sections (Garage)	15 min.
290	Roof Framing Plan	40 min.
130	Projection Coordination	2 hrs. 5 min.
	Total	22 hrs. 25 min.

Figure 6.28 Progress for a specific time period.

Document Numbering System

Although this book is mainly concerned with architectural working drawings, it also includes other drawings among those that constitute a complete set of construction documents. To keep all of the drawings in their proper spaces, they are numbered differently. For example, the set of architectural drawings can easily be identified by the letter A: Sheets A…100, A…200, A…300, and so on. In contrast, S can be used for structural drawings (S…100, S…200, S…300), E for electrical, L for landscape, and M for mechanical,

to mention but a few categories.

While the letter indicates a particular discipline, the number may indicate a type of drawing series. For instance the 100 series may represent the floor plans of a building and the 200 series may represent elevations and so on. The American Institute of Architects has a recommendation for all of these letters and numbers for an architectural firm.

A title sheet includes a legend of all the sheet titles, and page numbers are indicated so that recipients of a set of drawings will know if a page is missing.

Drawing Development

As indicated previously, most offices have a game plan. Although such plans may vary slightly from one office to another, Figure 6.29 displays what we feel is a rather typical sequence. The terms **layout** and **block out** in this list mean to roughly draw out so that changes and corrections can easily be implemented. Key or special notes (**keynotes**) refer to the fact that noting is vitally important and actually supersedes the graphic documentation or representations illustrated on the plans.

Working Drawing Procedures

PROJECT

1. Lay out Unit Floor Plans – ¼"
   __ Block out walls.
   __ Door and windows.
   __ Cabinets, appliances and fixtures.
   __ Dimension overalls.
   __ Calculate square footages.

2. Lay Out Roof Plan – ⅛"
   __ Indicate exterior line of building.
   __ Indicate roof lines and pitch.

3. Lay Out Building Sections – ¼"
   __ Indicate type of framing.
   __ Dimensions floor and plate heights.

4. Lay Out Exterior Elevations – ¼"
   __ Indicate doors and windows.
   __ Indicate exterior materials.
   __ Dimension floor and plate heights.

5. Lay Out Addenda Plans – ¼"
   __ Partial floor plans.
   __ Exterior elevations (per step #4)
   __ Roof plan (per step # 2)

6. Project Manager to Select Keynotes.
   __ Floor plans.
   __ Exterior elevations.
   __ Interior elevations.
   __ Sections.

7. Project Manager to Select Details
   __ Doors and windows.
   __ Exterior elevations
   __ Interior elevations

8. Project Manager to Lay Out Framing and Mechanical Study.
   __ Overlays.

9. Plot
   __ Floor Plans.
   __ Addenda plans/exterior elevations/roof plans.
   __ Sections.
   __ Submit package to structural, T-24 Engineers, and applicable consultants.
   __ In-house back check of package (Designer and project Architect.)

50% COMPLETE

10. Floor Plans
    __ Lay out electrical plan.
    __ Finish interior/exterior dimensions.
    __ Note plans.
    __ Reference details.

11. Lay Out Interior Elevations and Fireplaces – ¼"
    __ Indicate ceiling heights.
    __ Dimension cabinet heights.
    __ Dimension appliances.
    __ Note interiors.
    __ Dimension fireplaces.
    __ Note fireplaces.

12. Architectural Detail Sheets
    __ Finish all Details.
    Consultant design information due; in-house plan check and application to drawings.

13. Addenda.
    13.1 Partial Floor Plans
    __ Electrical.
    __ Dimension.
    __ Note-Plans.
    __ Reference details.
    13.2 Roof Plans – ¼"
    __ Reference details.
    __ Reference notes.
    13.3 Exterior Elevations
    __ Reference details.
    __ Reference notes.
    __ Exterior materials finish schedule.

14. Sections
    __ Reference notes.
    __ Coordinate consultant design.

15. Title Sheet
    __ Code tabulation.
    __ Consultant information.
    __ Vicinity map.
    __ Sheet index.

16. Final Coordination
    __ Building department submittal information.
    __ Final plotting for building department.
    __ Submit for plan check.

90% COMPLETE

17. Formal In-House Plan Check
    __ Plan check.

18. Building Department Plan Check
    __ Incorporate correction into plans.
    __ Coordinate client/cyp in-house plan checks and incorporate into plans

19. Signatures
    __ Upon building department approval (permit), route plan set for consultant approval and signatures

100% COMPLETE
Ready for plotting and submittal.

Figure 6.29 Working drawing procedure game plan.

Preliminary Approach with Computer Model

Following the initial design stages of whatever process is chosen, a massing study is used as a bridge between the design and construction documents (see Figure 6.30). The massing study is initially formed as a 3…D model on the computer, making the journey much easier. Review the steps described in Chapter 1 to better understand the process we will now embark upon.

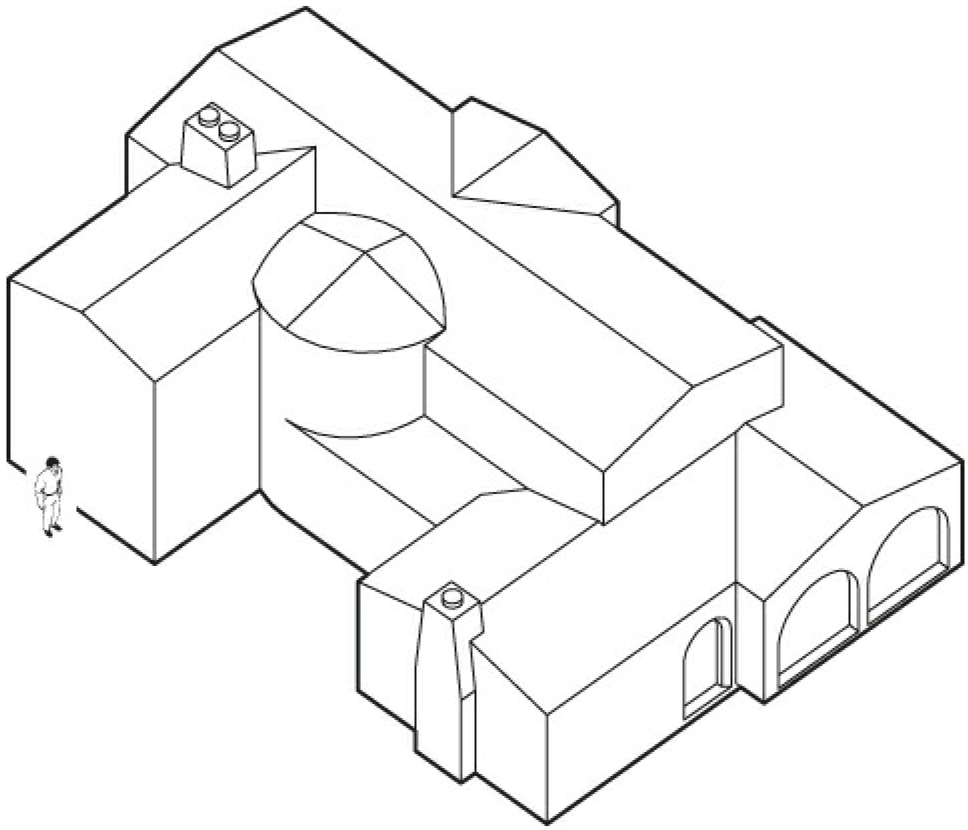


Figure 6.30 Preliminary massing model of the Clay residence.

Initially, the 3…D massing model is refined and adjusted to the client's needs (see Figure 6.31). The next step is to convert the refined 3…D model into a series of orthographic views. The top view becomes the roof plan, and the front, rear, and side views become the elevation (see Figure 6.32). This is the process of taking a building (drawn in 3…D) and slicing it. The horizontal slice produces a floor plan when the inside is detailed. The vertical slice becomes a building section when rotated into an ortho position (see Figure 6.35). A summary of the various views available via rotation can be seen in Figures 6.33 and 6.34.

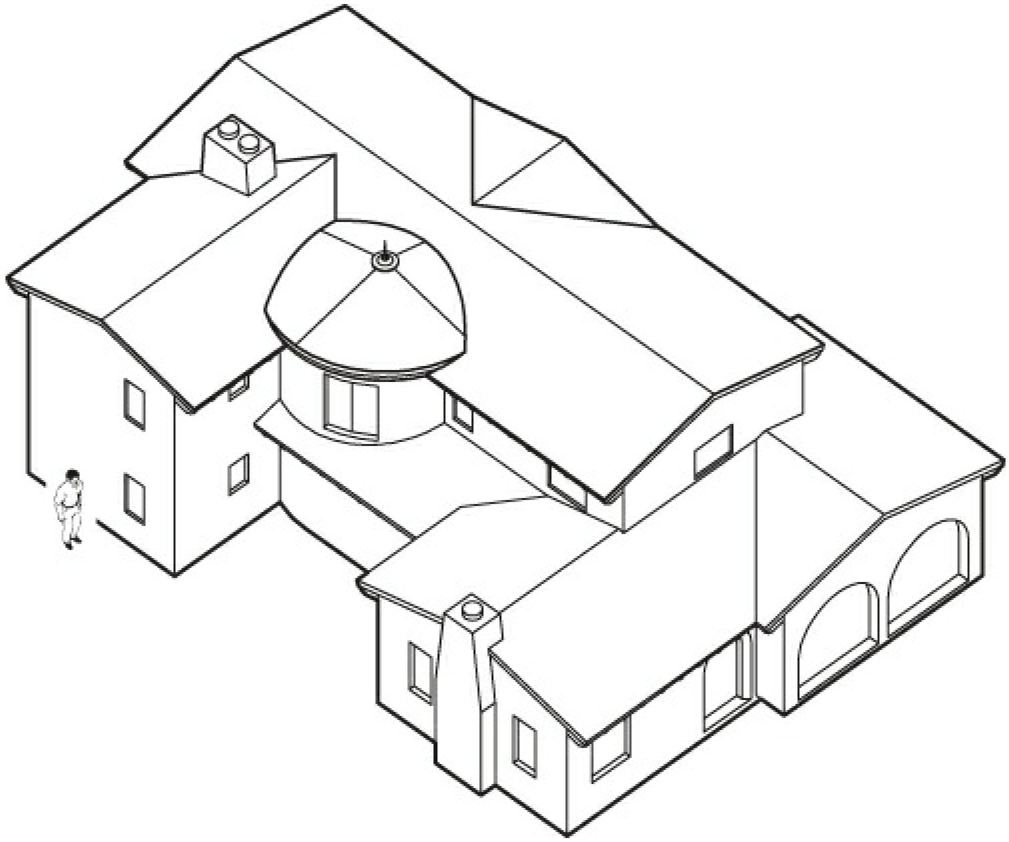


Figure 6.31 Refined 3…D model of the Clay residence.

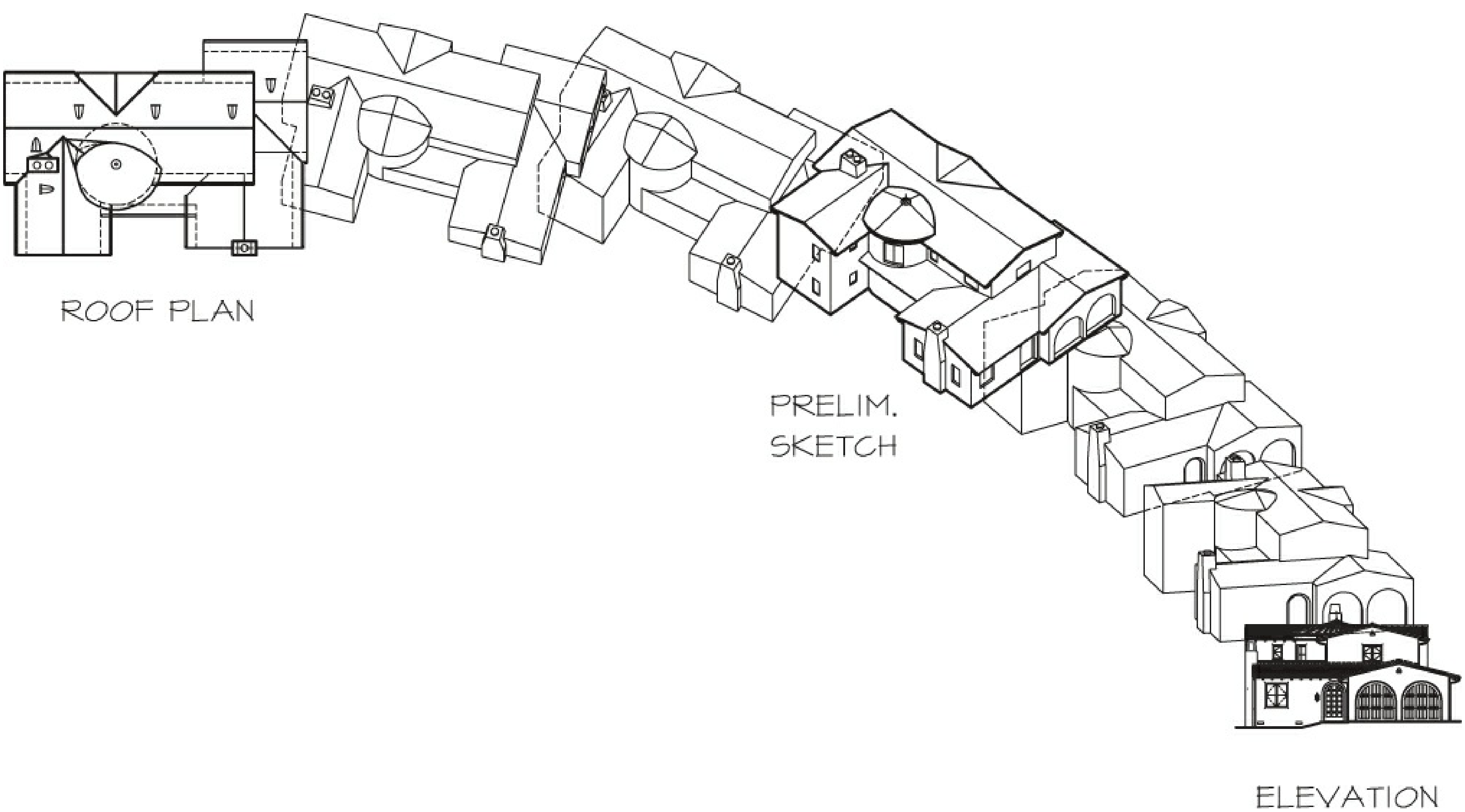


Figure 6.32 Rotation of massing model into orthographic view.

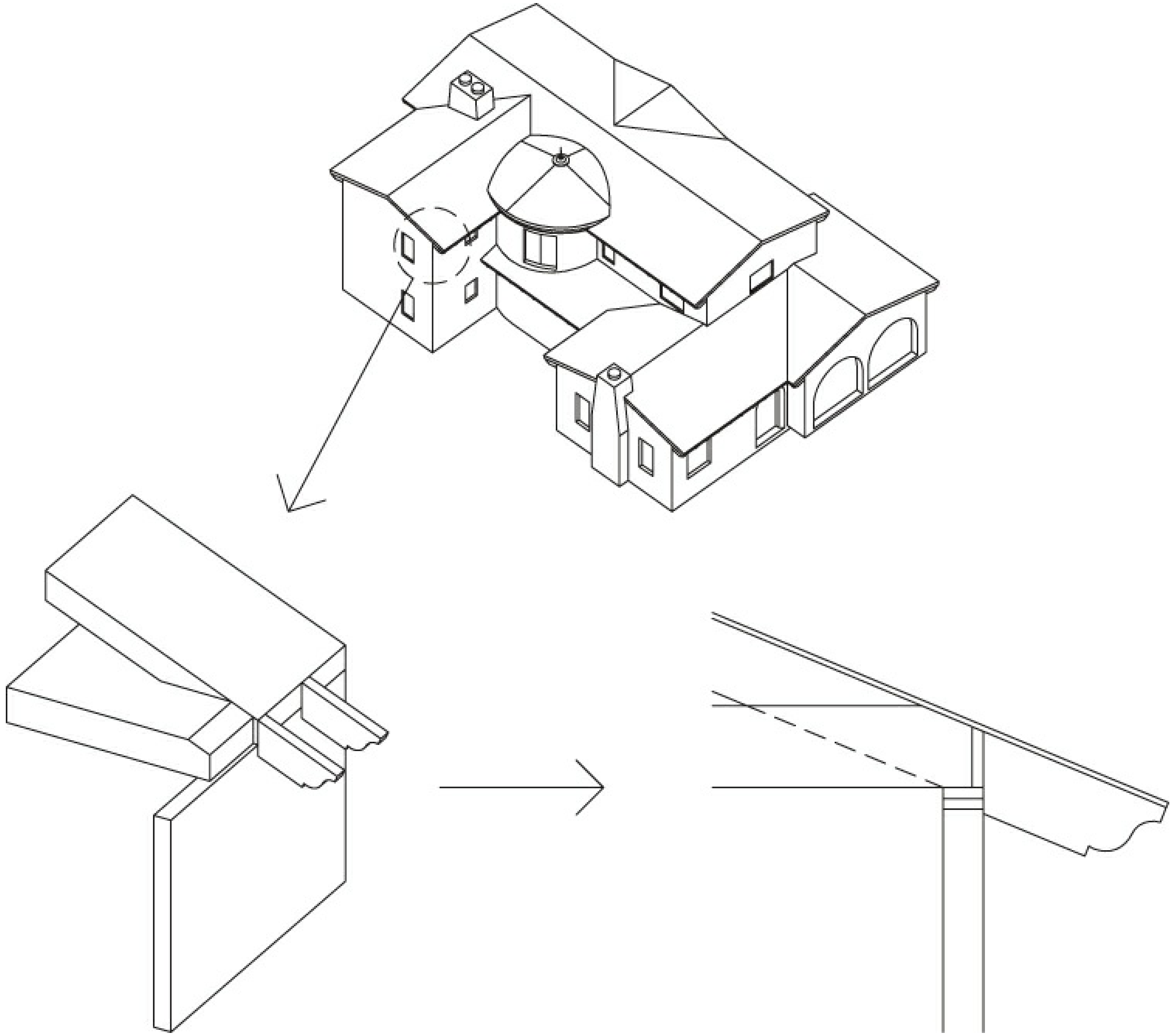


Figure 6.33 Isolation areas for detailing.

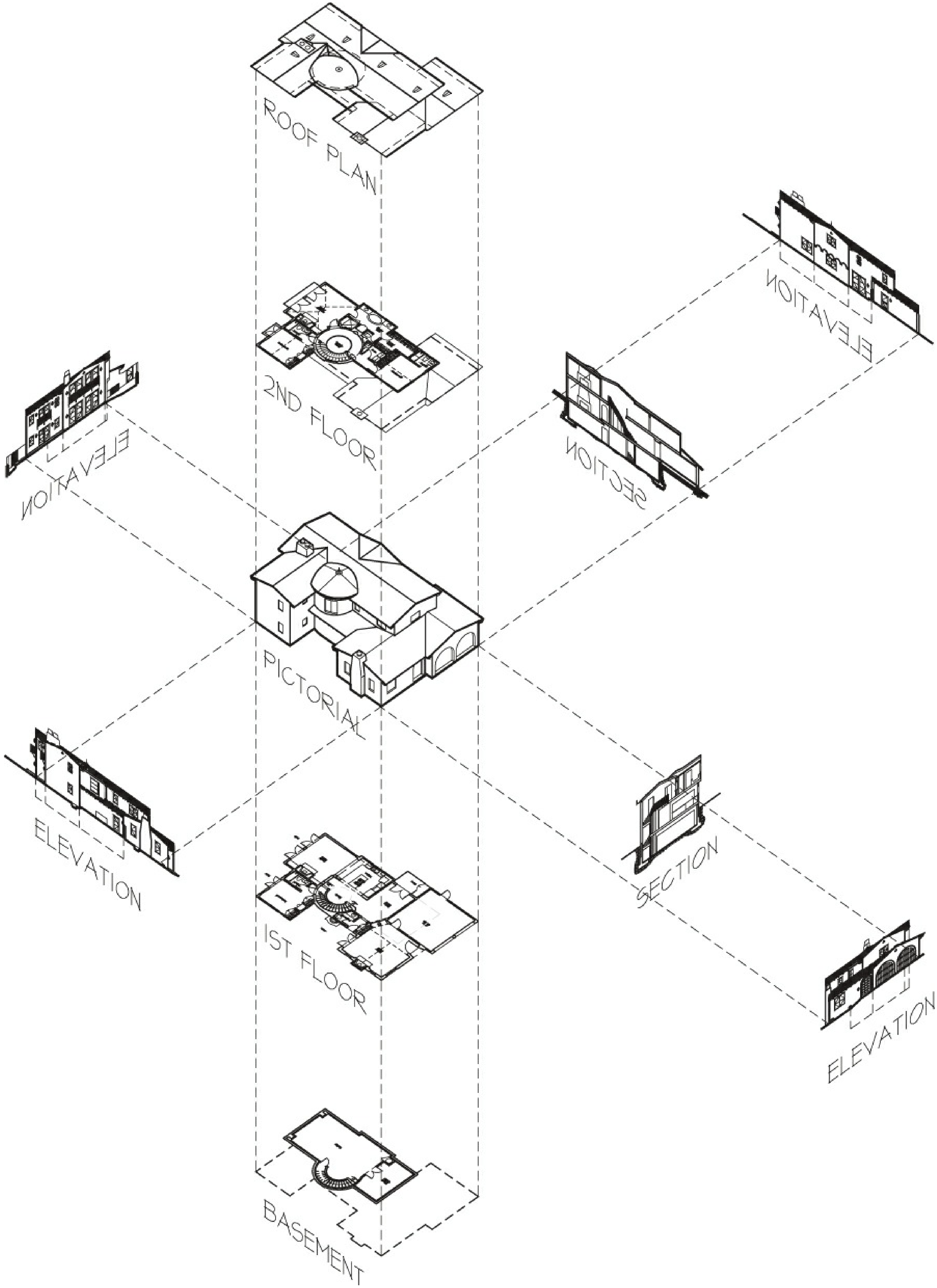
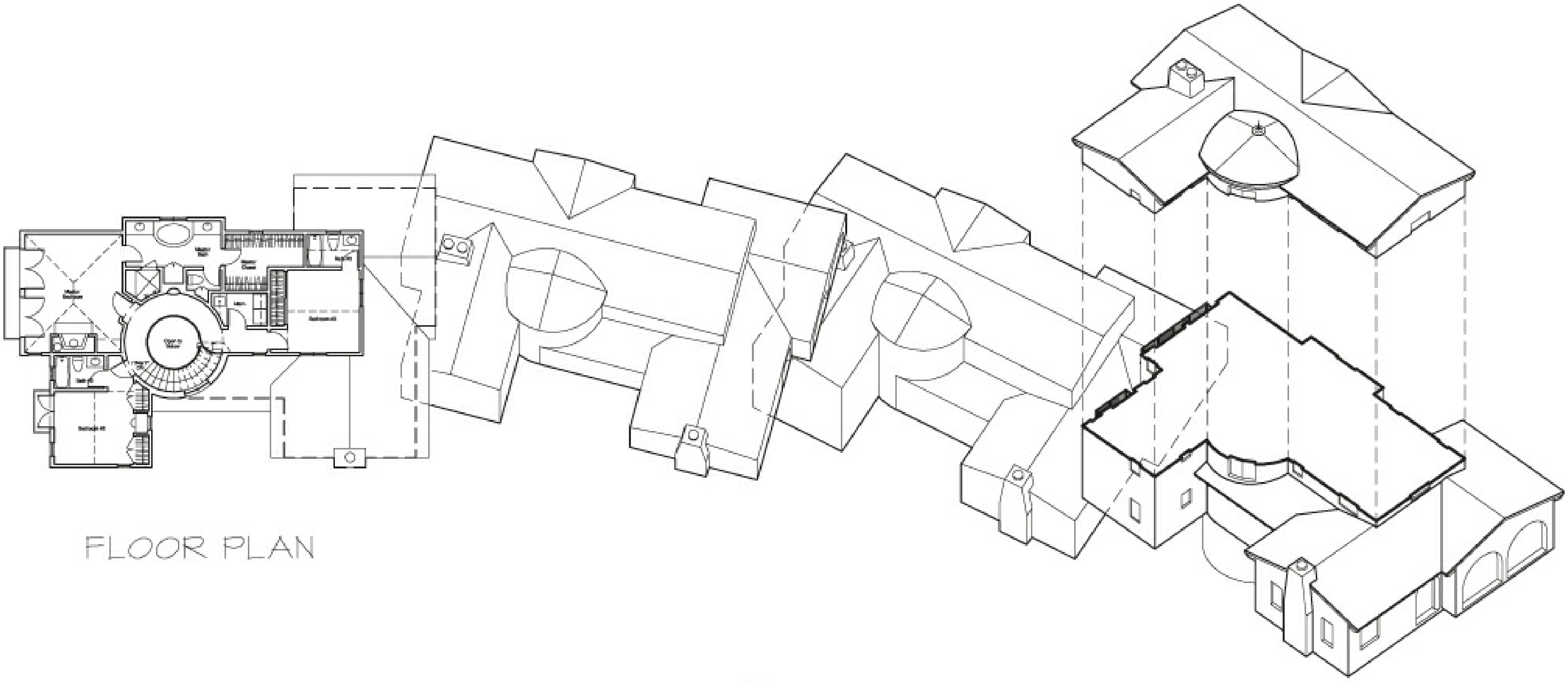
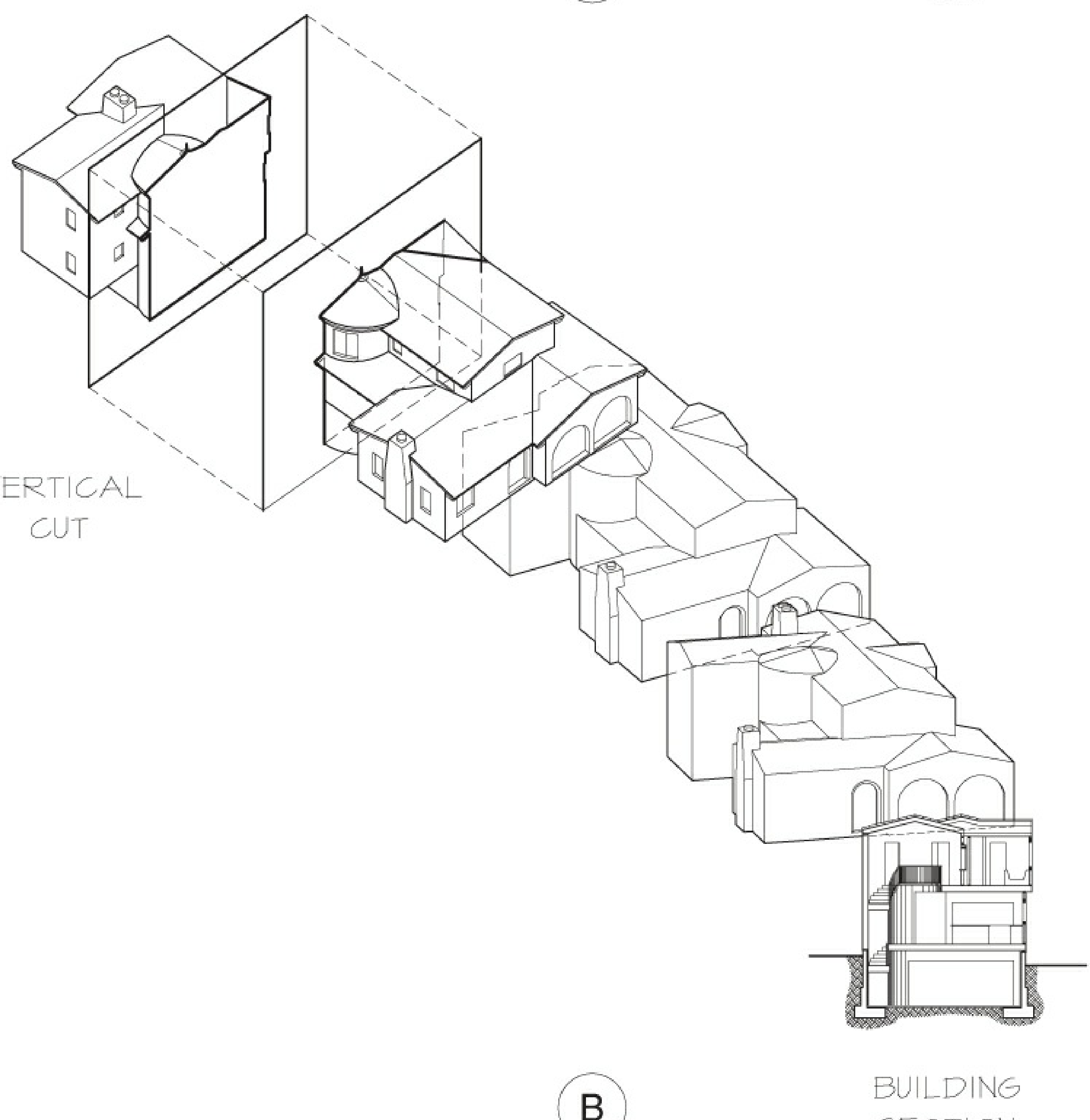

ROOF PLAN
2ND FLOOR
ELEVATION
SECTION
ELEVATION
PICTORIAL
ELEVATION
SECTION
1ST FLOOR
ELEVATION
BASEMENT

Figure 6.34 Evolution of construction documents.



A



B

Figure 6.35 Horizontal and vertical sections through preliminary sketch.

Stages and Layers of Production Drawings

The pictorial and preliminary floor plan shown in Figure 6.36 can be scanned and used as a construction layer for computer drawings. If the 3‐D model is digital, we can then rotate the object into the required views as described earlier.

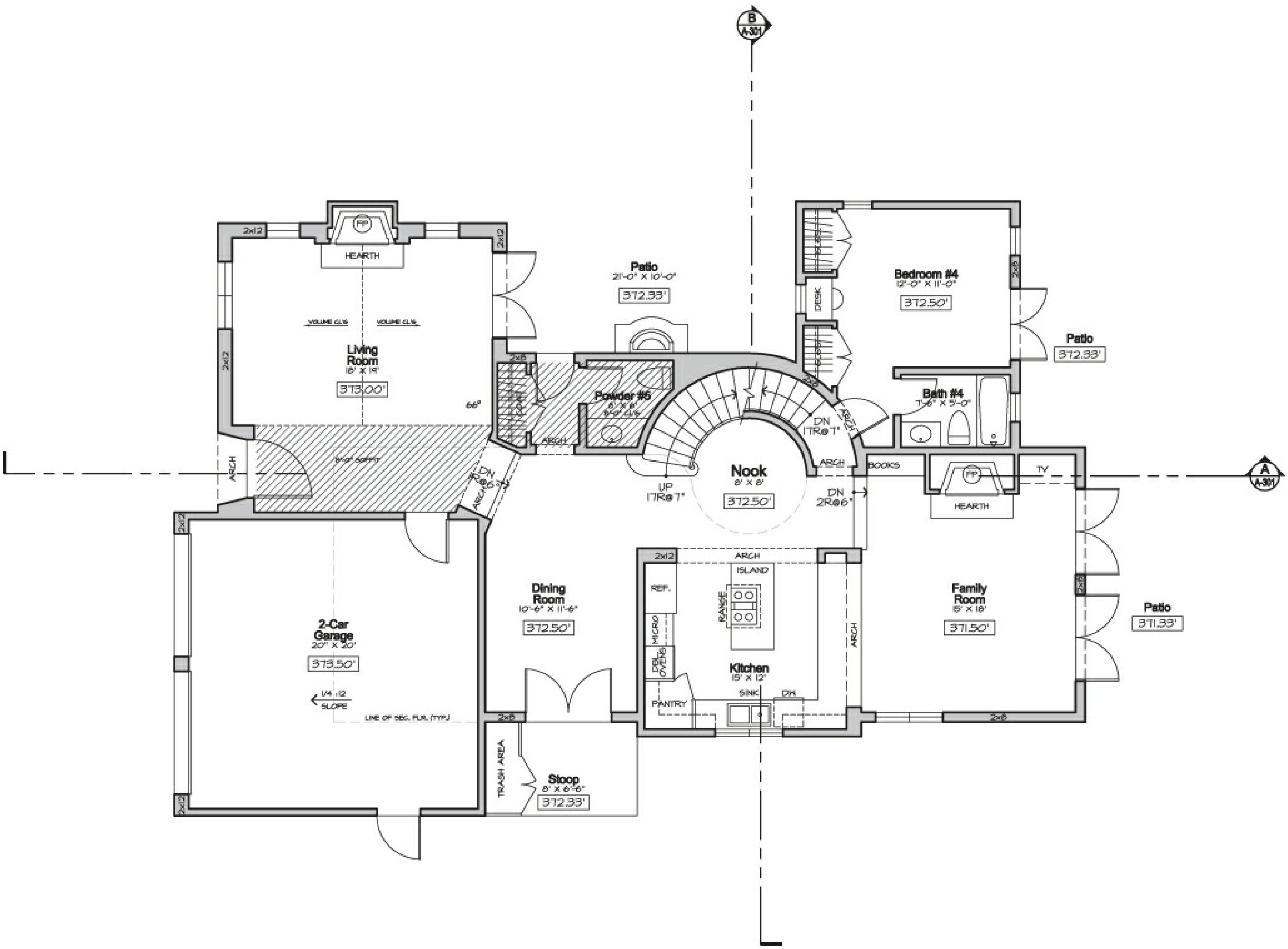


Figure 6.36 Pictorial and preliminary floor‐plan layout.

Producing the initial stage of working drawings by rotation sets the stage for the following five to six stages of layers to be produced by the CAD drafter. More complex projects may call for more stages, but we think that five is the absolute minimum number of stages for any set of construction drawings.

Stages

Stage I (Figure 6.37). The floor plan becomes the basic pattern for all other drawings in the set. If a computer is used, grids and snaps are set to produce the preestablished modules, such as a block module when masonry is used or a matrix for

steel.

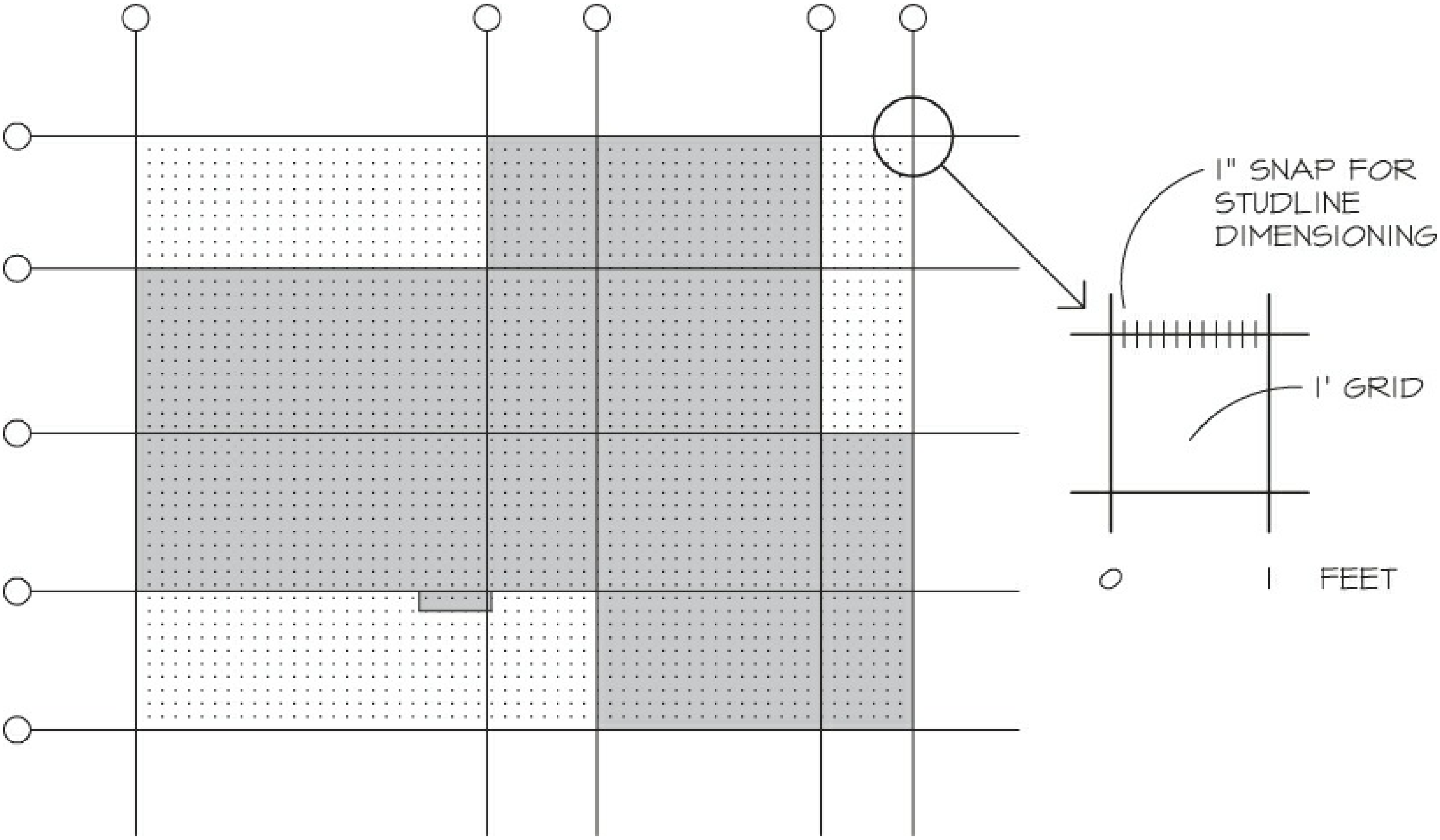


Figure 6.37 Stage I: Floor…plan datum layer.

Stage II (Figure 6.38). The interior and exterior walls with their limits are drawn in this stage. Columns and openings should also be included at this stage. The designer called for rounded corners. Figure 6.39 shows a pictorial and a detail of how this is accomplished. This stage may become the datum stage for the foundation plan.

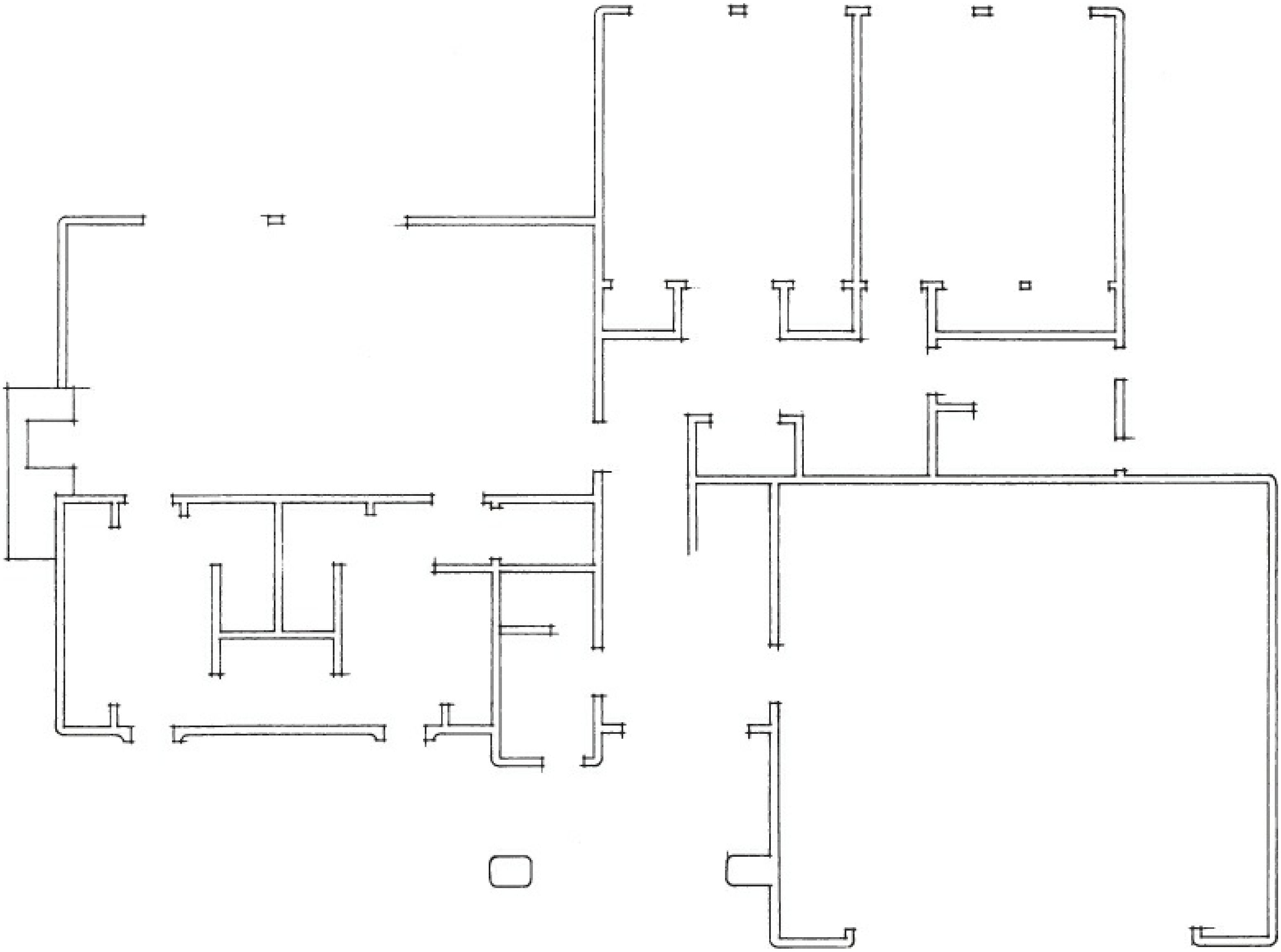
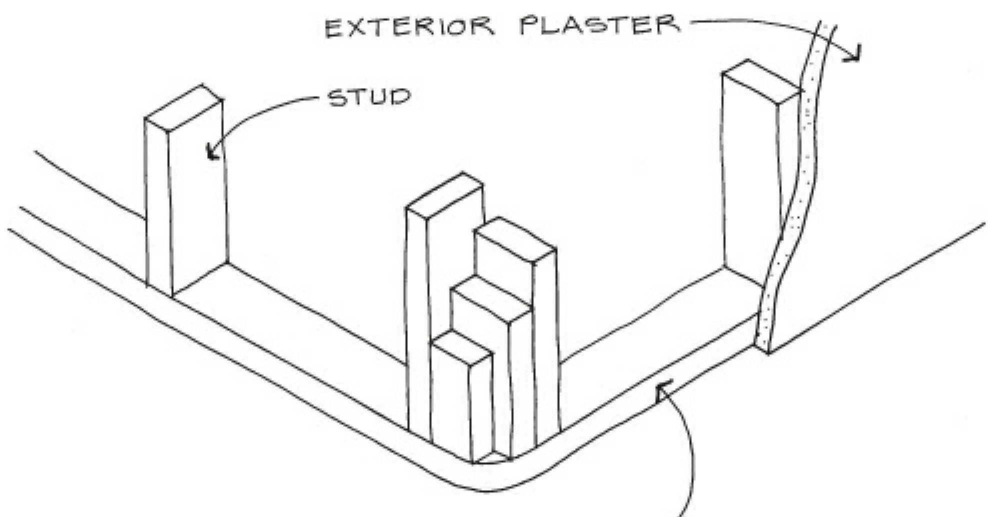


Figure 6.38 Stage II.



Pictorial of the framing for a rounded corner

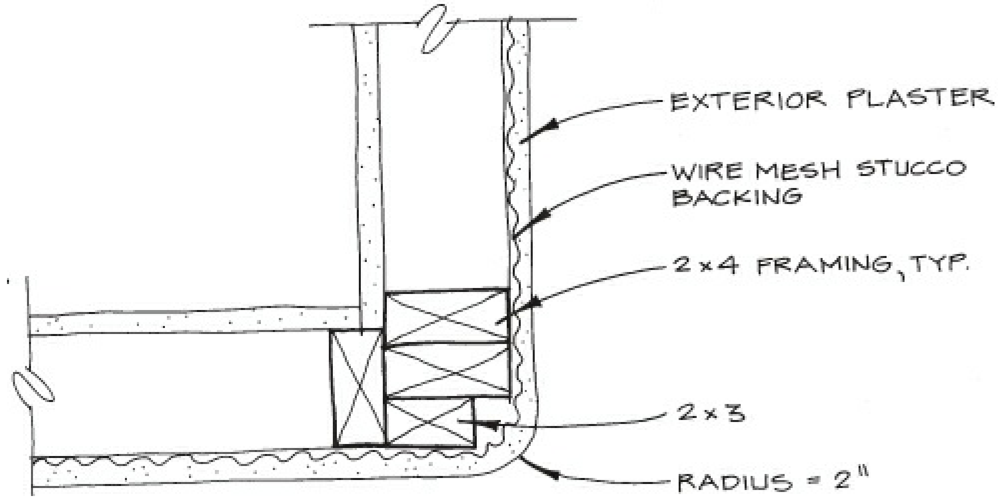


Figure 6.39 Framing at rounded corners.

Stage III (Figure 6.40). Stair positioning is critical at this stage. Plumbing fixtures also become a critical part of the drawing. For an office, partitions are frequently drawn at this stage, as are non…load…bearing walls and the positions for openings and doors not previously positioned by rotation of the 3…D model.

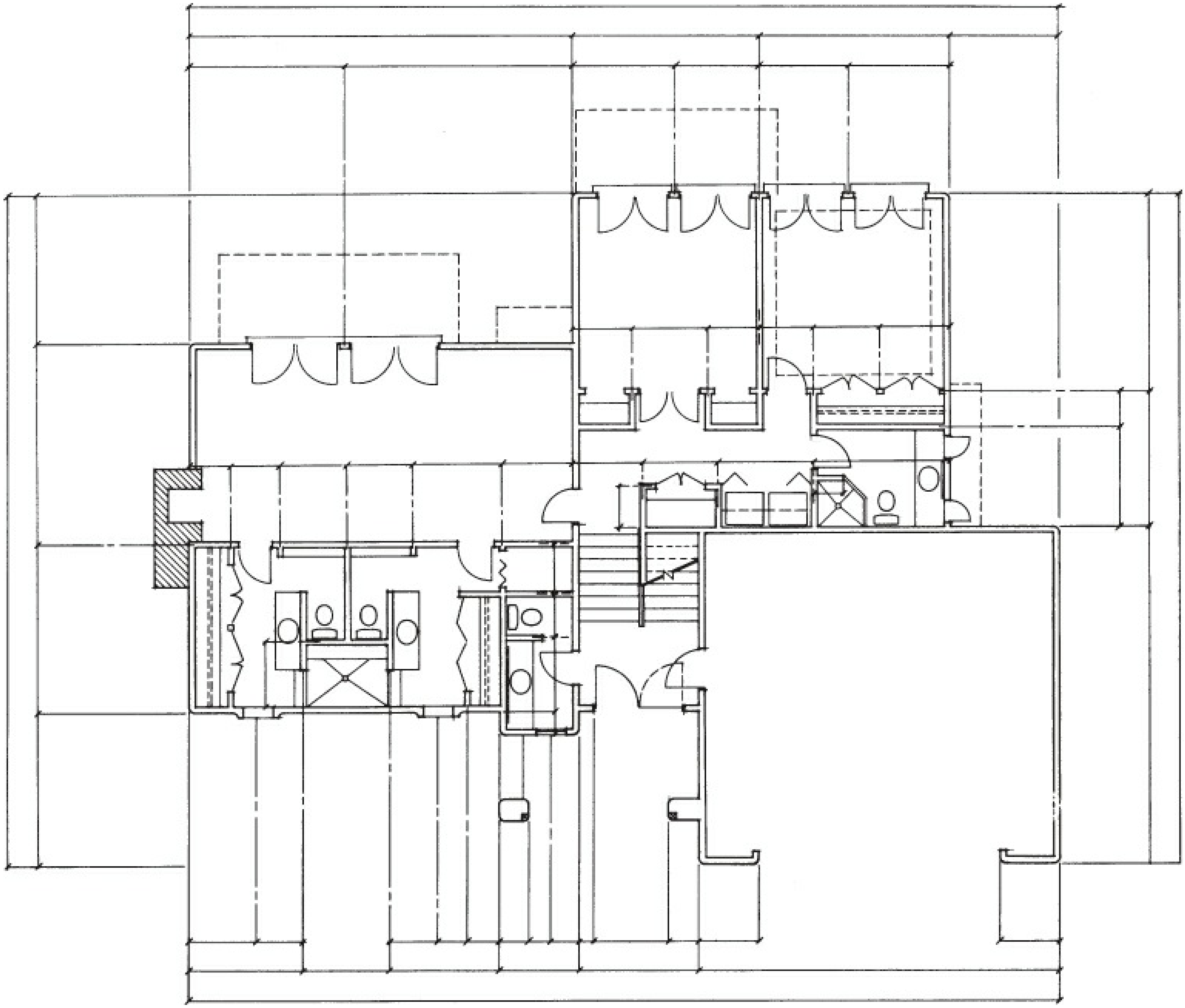
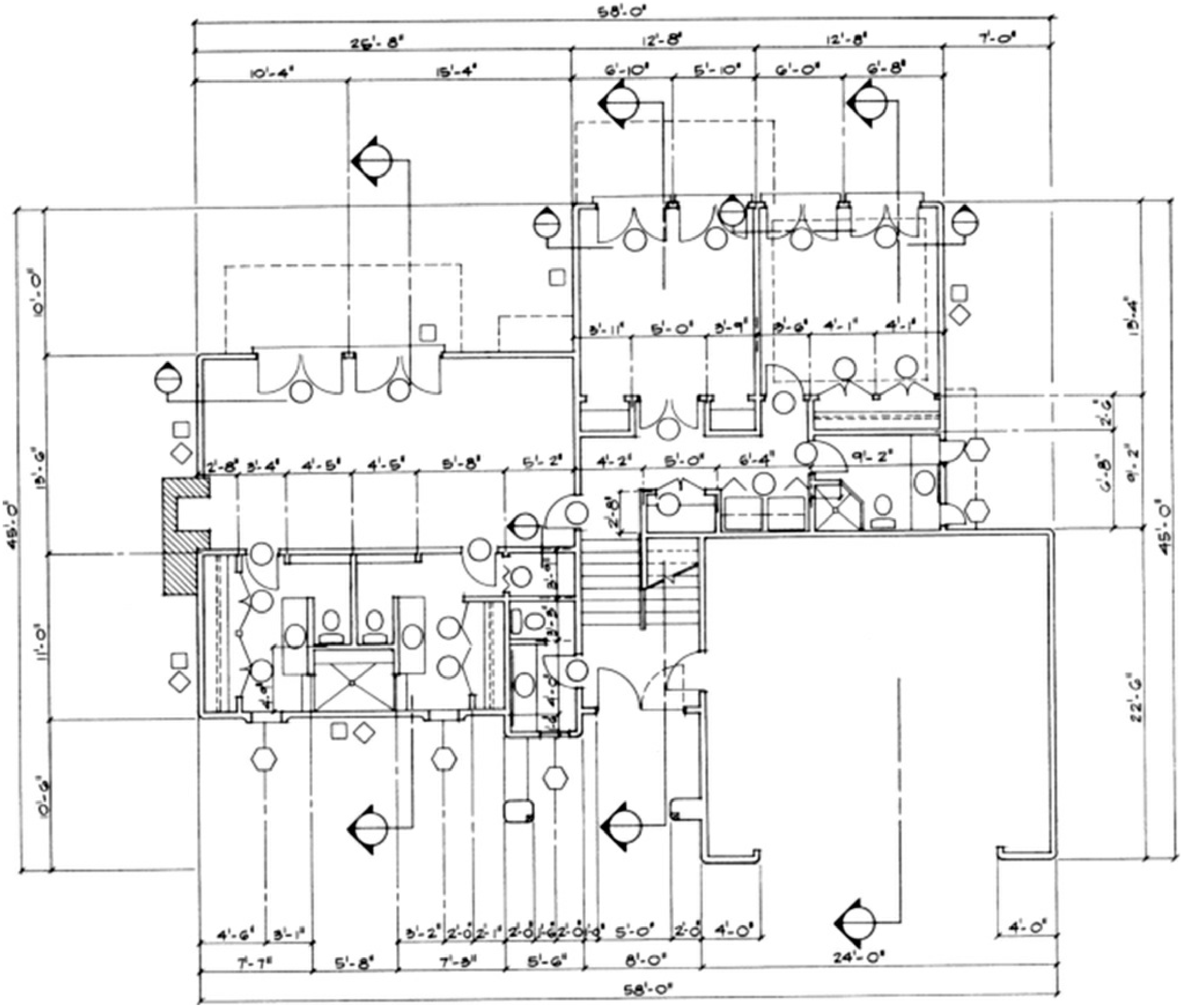


Figure 6.40 Stage III: Stairs and plumbing fixtures.

Stage IV (Figure 6.41). Dimensioning, including values, is accomplished here. You must dimension to face or center of stud for wood, follow a block module for masonry, and position the columns correctly using the axial reference plane method for steel.



[Figure 6.41](#) Stage IV: Dimensioning and material designation.

Stage V ([Figure 6.42](#)). The drawing is cross‐referenced with other drawings, plans, sections, and details.

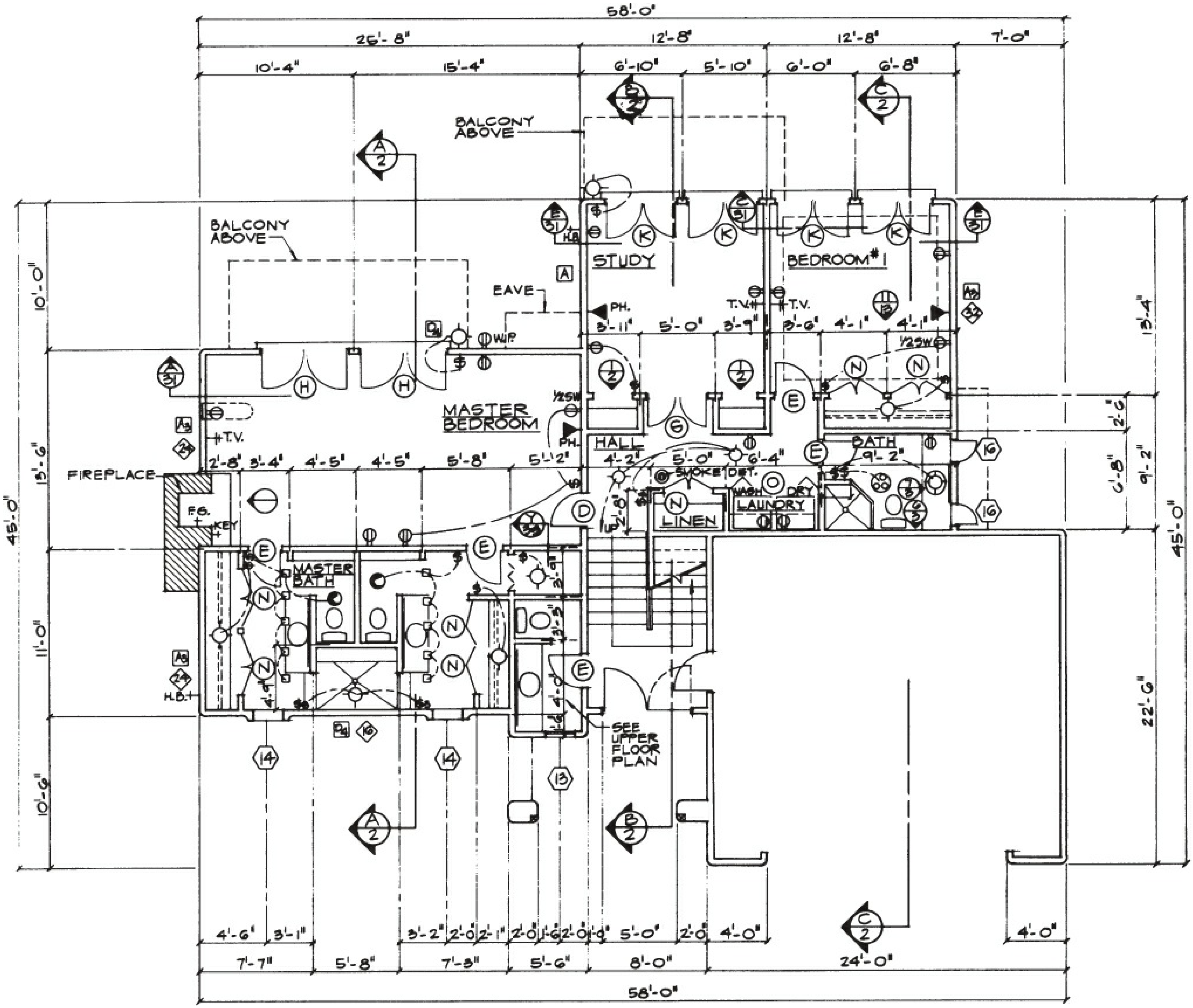


Figure 6.42 Stage V: Referencing.

Stage VI (Figure 6.43). All text and titles should be placed on one layer. Refer to the standard for typeface, size, and positioning.

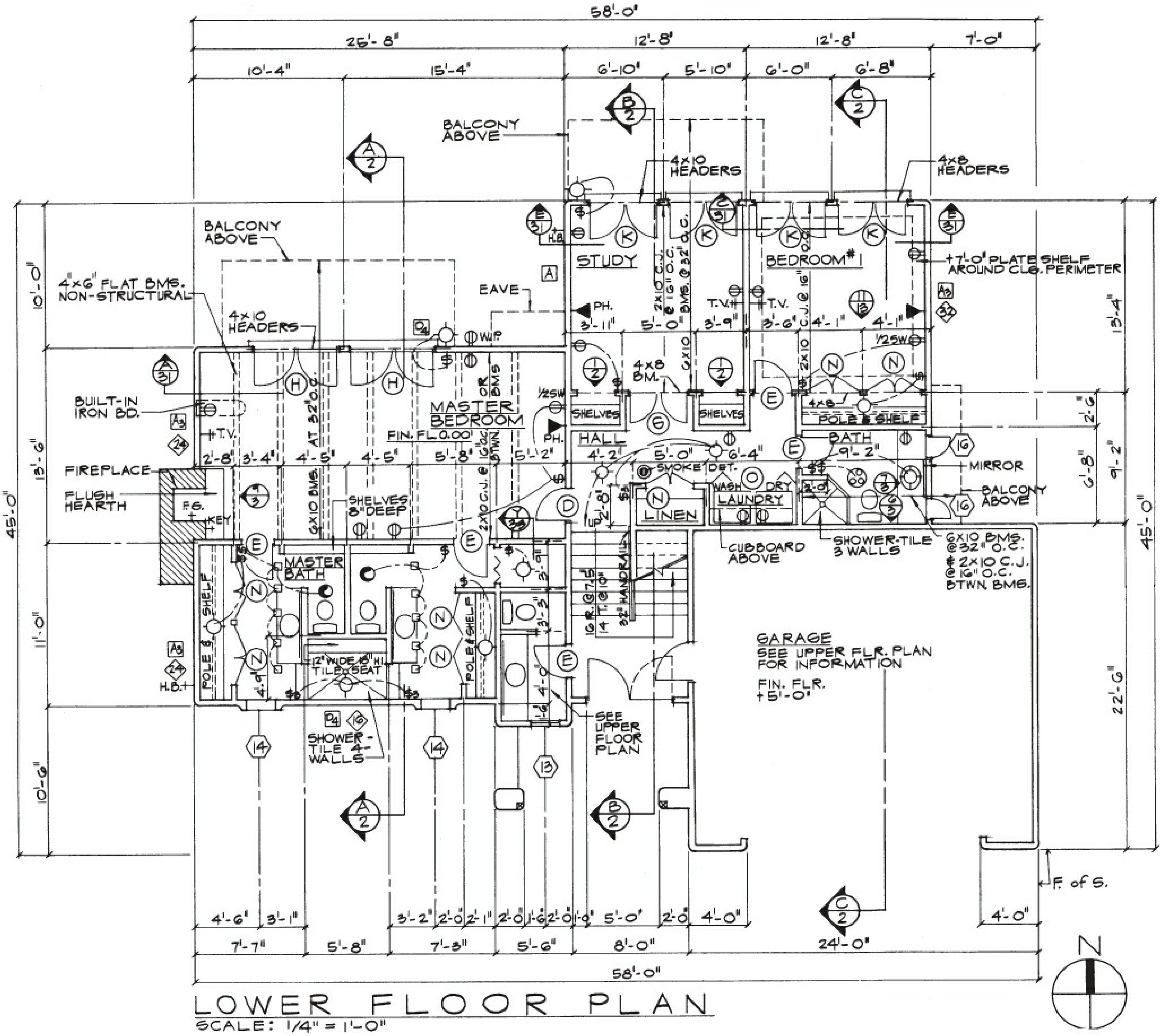


Figure 6.43 Stage VI: Final plot sheet of lower floor plan.

Stages and layers may appear to be the same to the beginning CAD drafter, but in reality they are different. An example is the floor plan shown in Figure 6.36. This is a drawing done in six or seven stages, but there are as many as 15 layers. The greater the number of layers, the easier it is to change or alter the drawing. As any office employee will tell you, there is nothing more constant than change. The importance of being able to alter a drawing easily then becomes paramount.

The stages are a guideline of how to create construction drawings. BIM does not follow a strict set of guidelines; it allows the drafter to provide data as the data are received and does not have to get input in a linear pattern. For instance, if it is determined that the exterior walls will be 2 × 6 studs and the interior walls are 2 × 4 studs, the wall type can be created without drawing a single line. This typically occurs in Stage 2 of CAD drawing. Also, with BIM, Stage 5 is automatically determined in the parametric referencing system

built into the software and will aid in a more organized method of development.

Additional layers may have to be developed as needed. An example of this is the text titled "ANNO" (annotation). The text layer can be divided into a multiple number of layers. One layer may be used for room titles only, a second layer may be used for general construction notes, and all other incidental notes may be on a third. An architectural office may utilize a standard layering practice as proposed in the national standards, or it may develop its own office system method.

The final plot sheet of the first‐floor plan of the Clay residence is shown in Figure 6.44. This sheet has 20 layers, but many of the layers have been combined, resulting in a set of drawings with 11 layers:

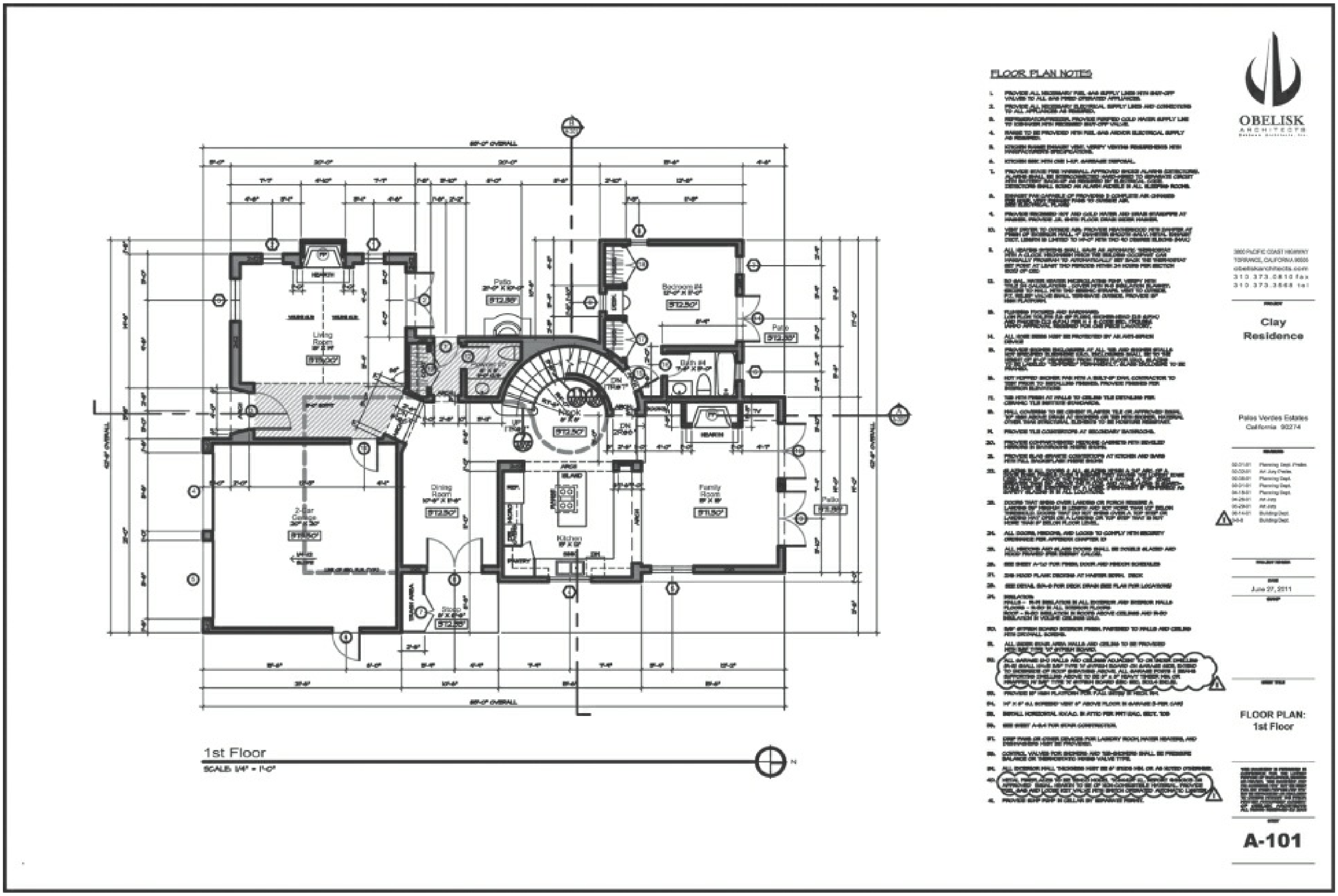


Figure 6.44 Plot sheet: First‐floor plan.

1. Plot sheet. Figure 6.44 includes the title block and the notes on separate sheets.
2. The floor plan is divided into the following layers:
   A. *Datum layer—Figure 6.45*. This layer shows the perimeter layout for a block module if the building is made of masonry. Space is plotted at the given module if a module is used (e.g., 50″ module). If steel is used, the module at which the steel columns are set by the structural engineer appears (e.g., 10′‐0″ o.c.). When the

structure is to be framed in wood, the grid may be set at 1…foot increments and the snap at 1…inch increments for stud line dimensioning. Whatever the game plan is for the structure in question, the datum layer becomes the pattern by which all other drawings are established and on which they are based. This perimeter drawing can be used to estimate square footage or to estimate the perimeter of the form.

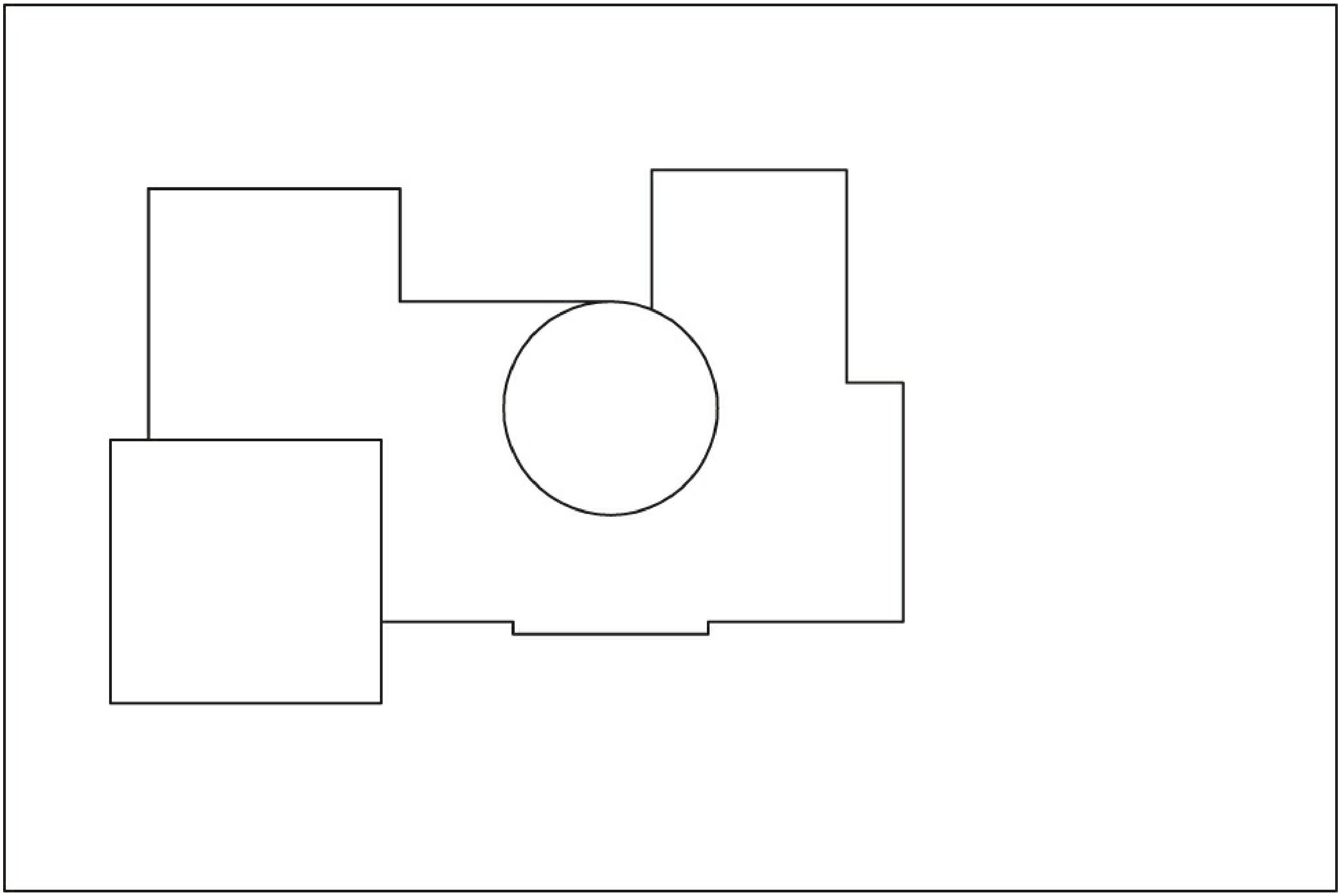


Figure 6.45 Master: Datum layer.

Figure 6.46 All walls are drawn on this layer. It may be split further into two additional layers, one showing bearing walls only, and non…bearing walls on the other. If a wall is moved, one can see immediately whether it is a load…bearing wall that affects the structure or a non…bearing wall that does not affect the calculation or engineering of the structure.

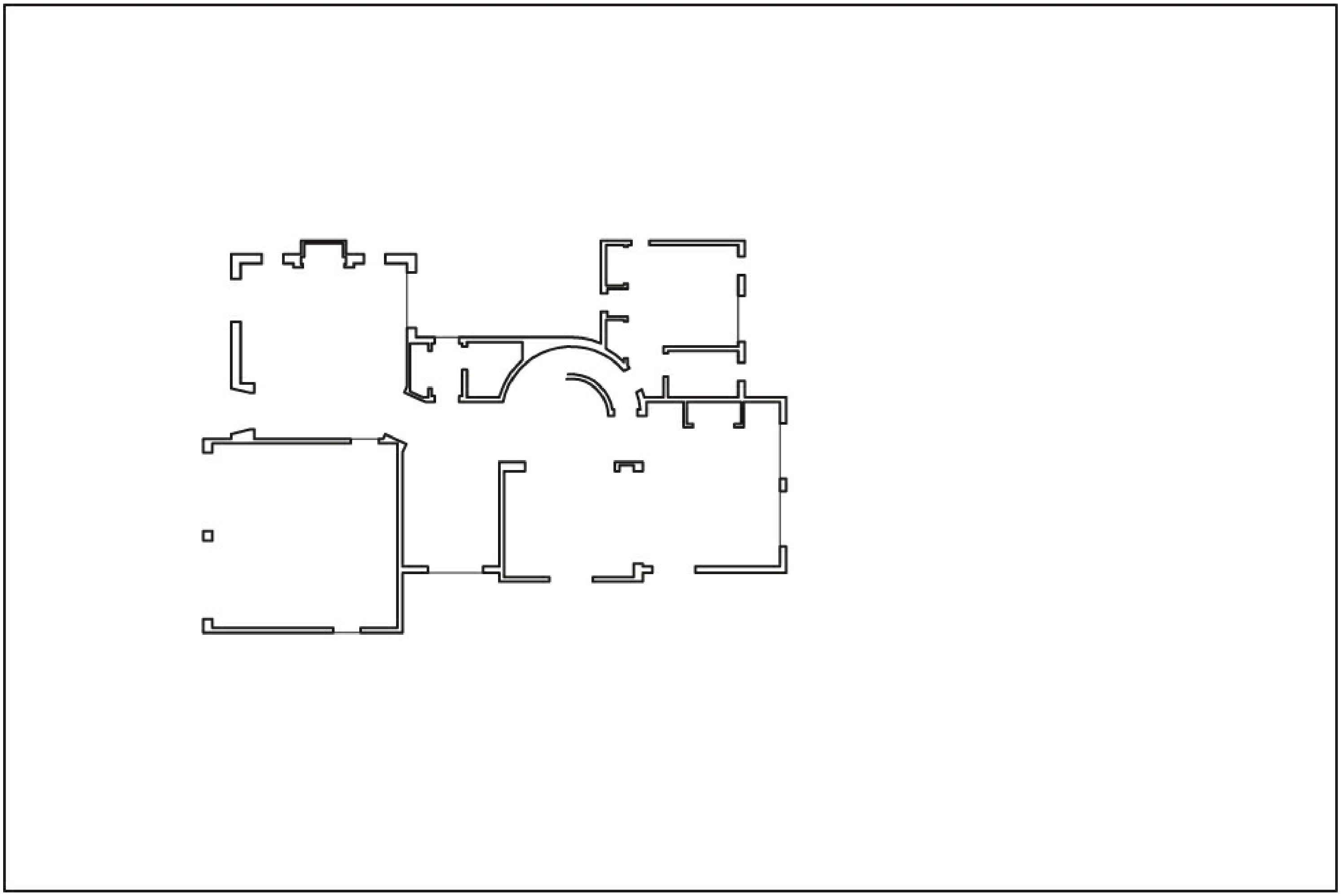


Figure 6.46 Master: Wall layer.

B. *Figure 6.47*. Plumbing fixtures, stairs, cabinets, and fireplaces are drawn on this floor layer. They can also be drawn on separate layers.

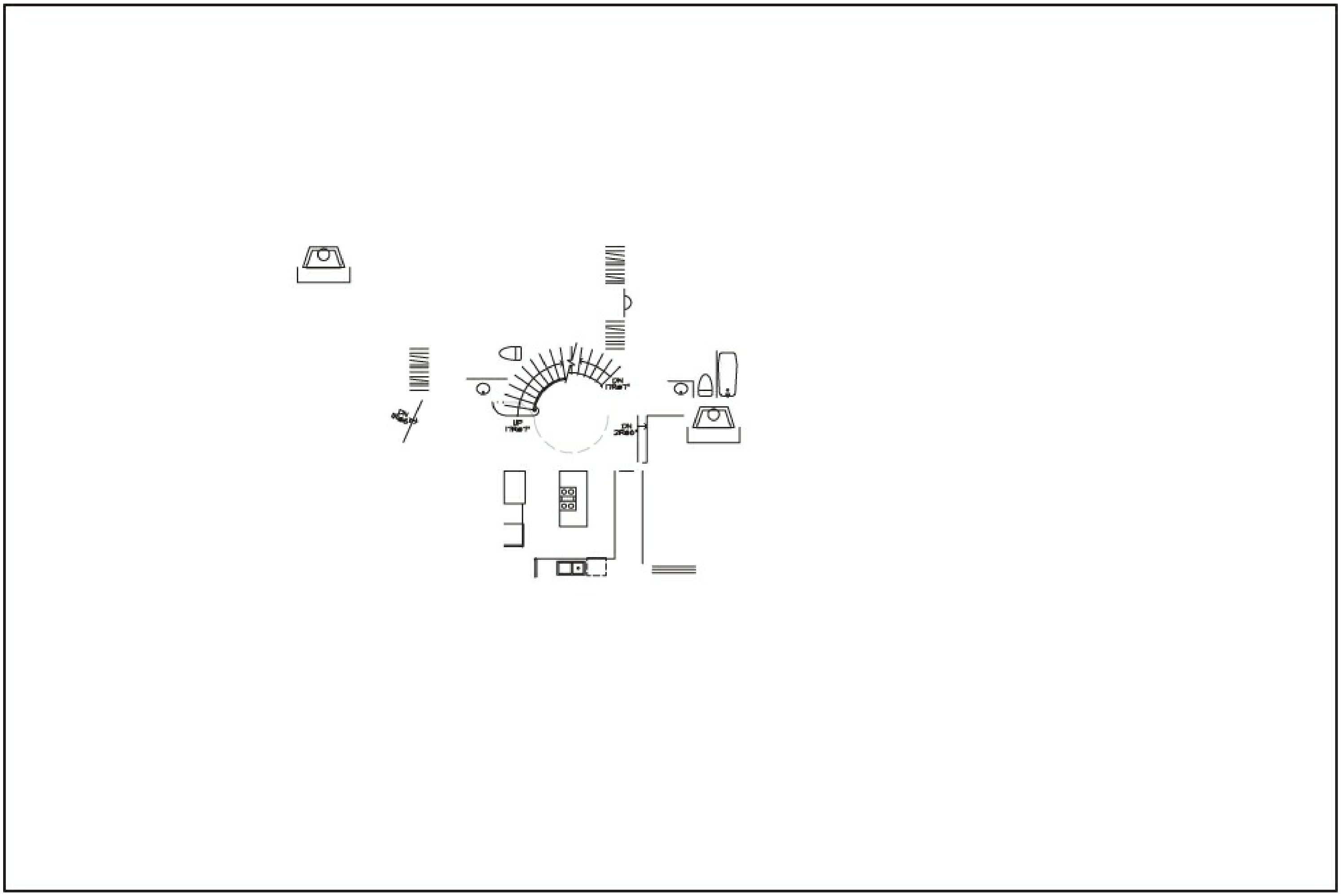


Figure 6.47 Master: Floor layer.

C. *Figure 6.48*. All hidden lines are drawn on this layer. They may be outlines of cabinets, soffits, or ceiling level changes. Whatever the reason for using hidden lines, they are placed on this level, avoiding the need to change line types within a layer. This too can be divided into wall and floor layers.

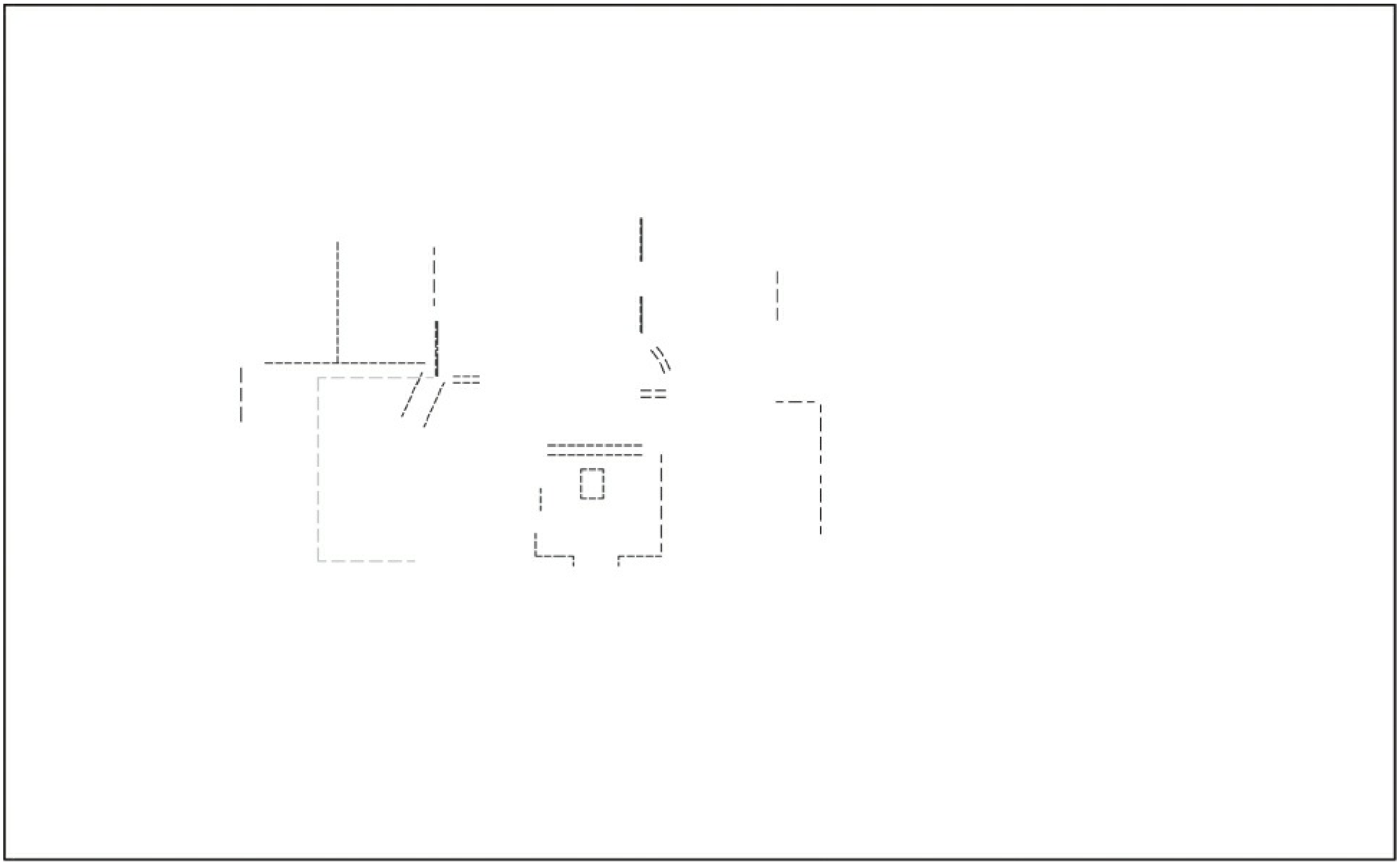


Figure 6.48 Master: Wall and floor hidden layer.

D. *Figure 6.49*. Because openings were positioned on a previous layer, the conventions used to identify doors, windows, and, in some instances, large cabinets are drawn at this point. As can be seen on this layer, the doors that lap are identified. It will also help later in the positioning of light switches to ensure that none are placed behind doors.

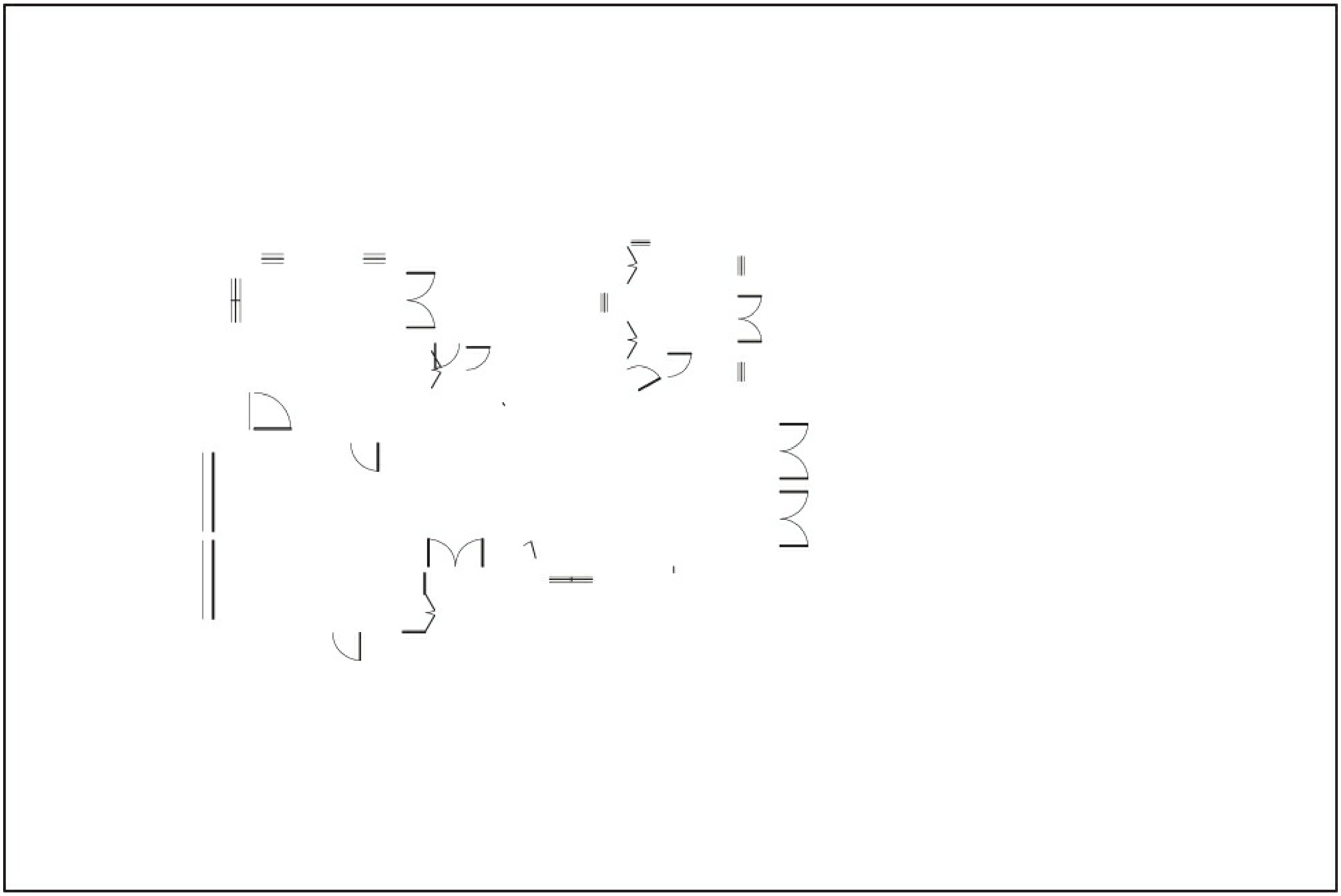


Figure 6.49 Master: Door and glazing layer.

E. *Figure 6.50*. This is the most critical of all of the layers in this set because it establishes the parameters and limitations for all the other drawings, elevations, sections, framing, and so forth. The numerical values must adhere to the module being used. If the structure is a wood stud construction, the dimensions must be set to face of stud (outside walls) or center of stud (inside walls). They must be positioned so the workers in the field (carpenters in this instance) can immediately find them and use the measurements efficiently and accurately. Dimension everything. Do not force the carpenters to compute figures. Be sure the total equals the sum of its parts.

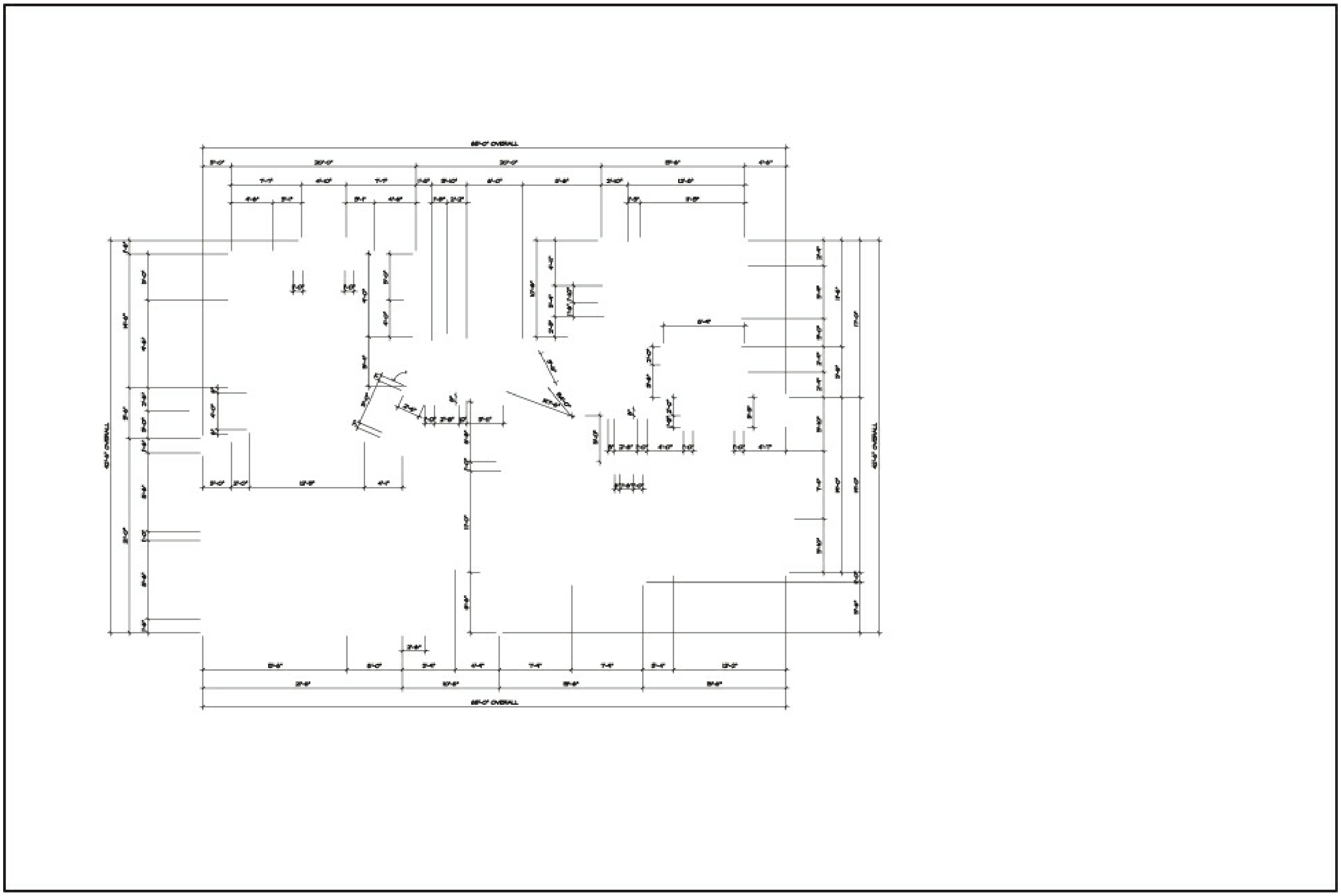


Figure 6.50 Master: Dimensions layer.

F. *Figure 6.51*. This is the lettering layer. In most instances, it is split into two layers, one for room titles and another for lettering. The name of the drawing, north arrow, scale, and any other office…standard titling identification can be placed on a third lettering layer.

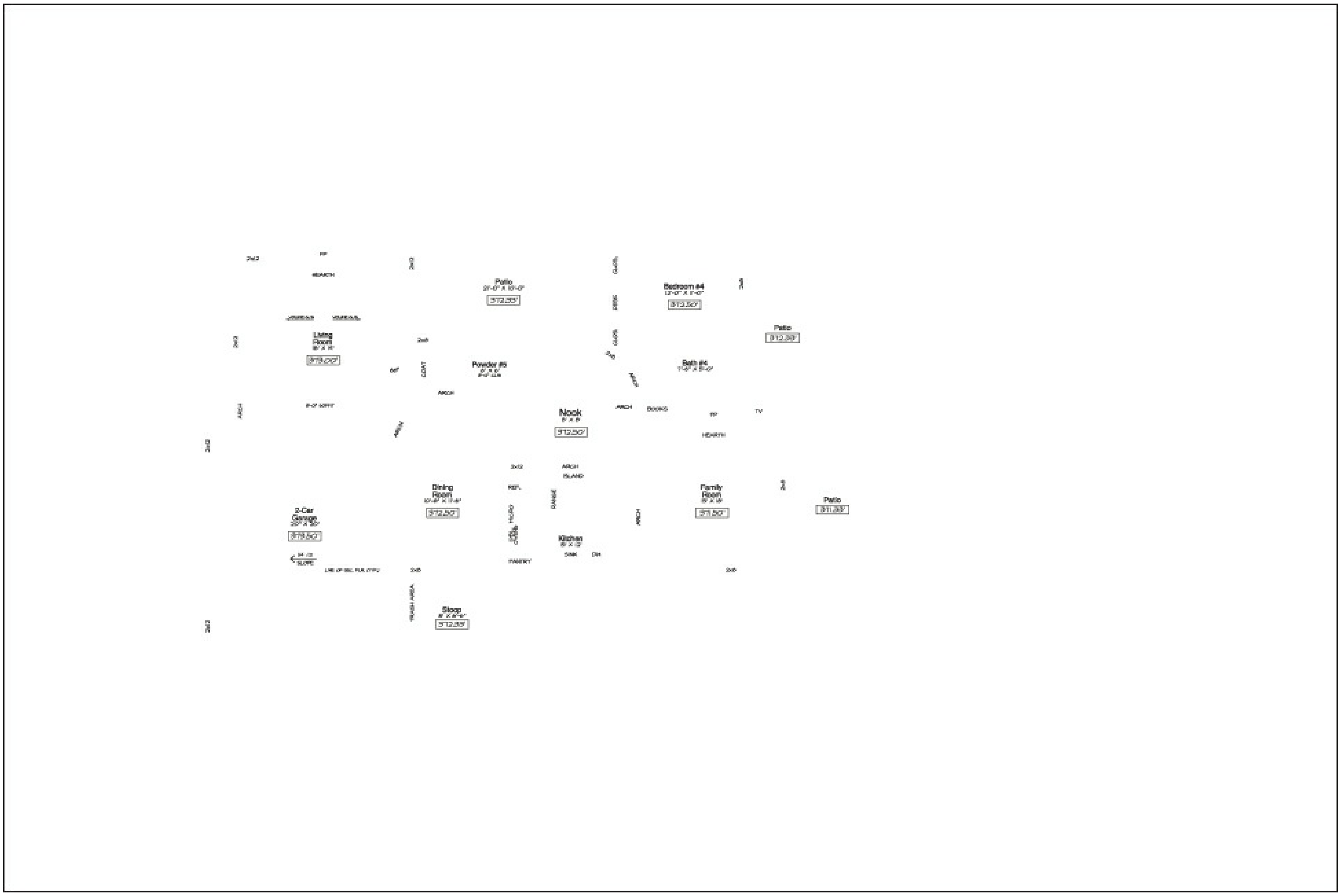


Figure 6.51 Master: Annotation layer.

G. *Figure 6.52*. Walls can be pochéd or hatched (darkened) on this layer. For the floor plan, all walls are shaded in the same intensity. On a framing plan, the bearing walls can be shaded dark and the non…bearing walls left unhatched. Patterns for furred ceilings, floor material, fireplace hearths, and any other patterns can be done on this layer or, again, as in previous layers, split into multiple layers if the patterns are complex.

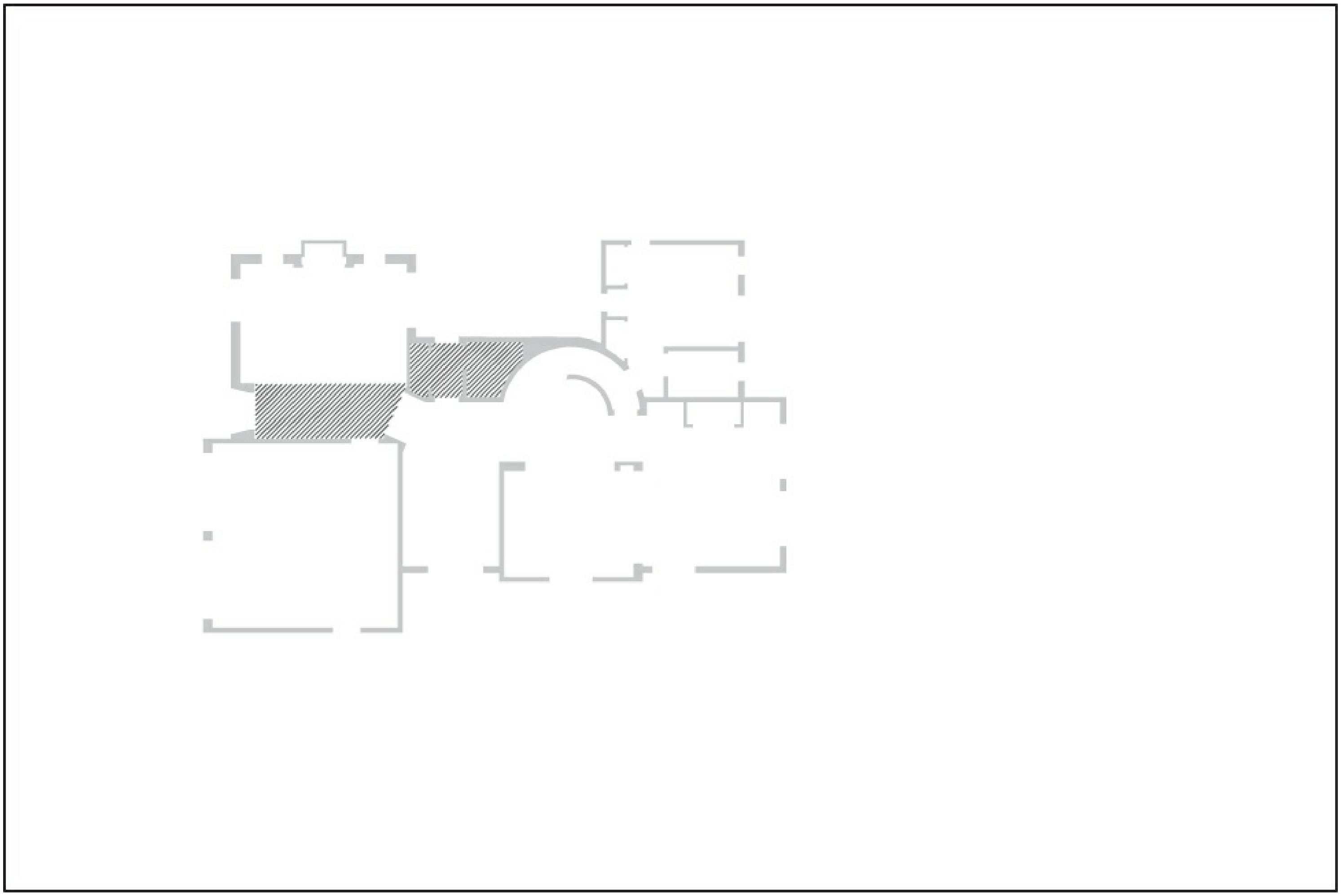


Figure 6.52 Master: Pattern and poche layer (hatch).

H. *Figure 6.53*. This section and symbol layer is a critical communicative layer. It references one area of a drawing to a detail, schedule, or building section. You will notice reference bubbles for a variety of referrals. Each of these can be placed on a separate layer.

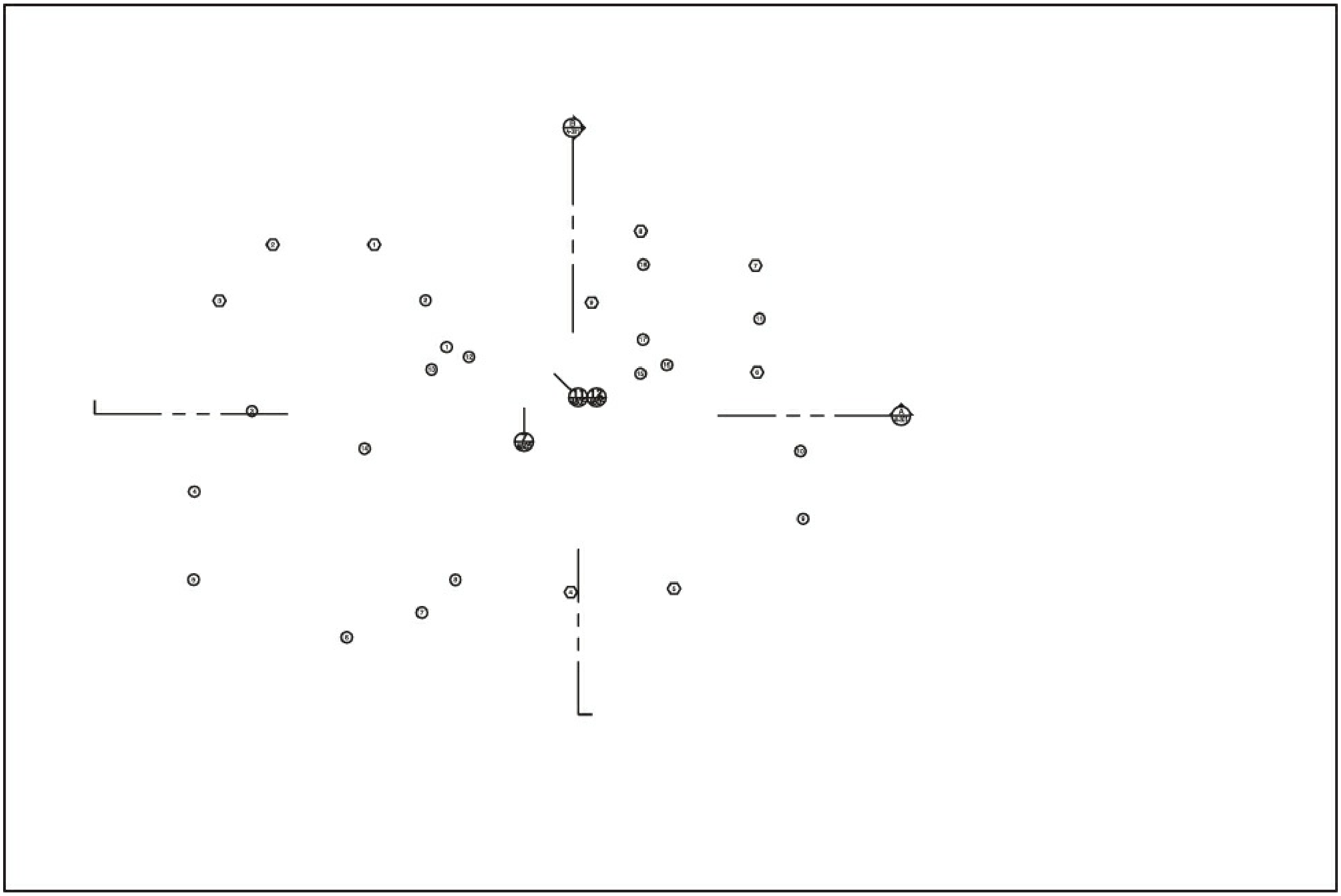


Figure 6.53 Master: Section and symbol layer.

I. Patios, barbeques, and other outside forms that do not affect the floor plan, yet set the proper context for the floor plan, can be placed on another layer. The outside forms on this floor plan were so minimal that an example is not shown.

J. *Figure 6.54*. XREF(ed) and positioned on all sheets is the standard office title block and notes (Figure 6.55).

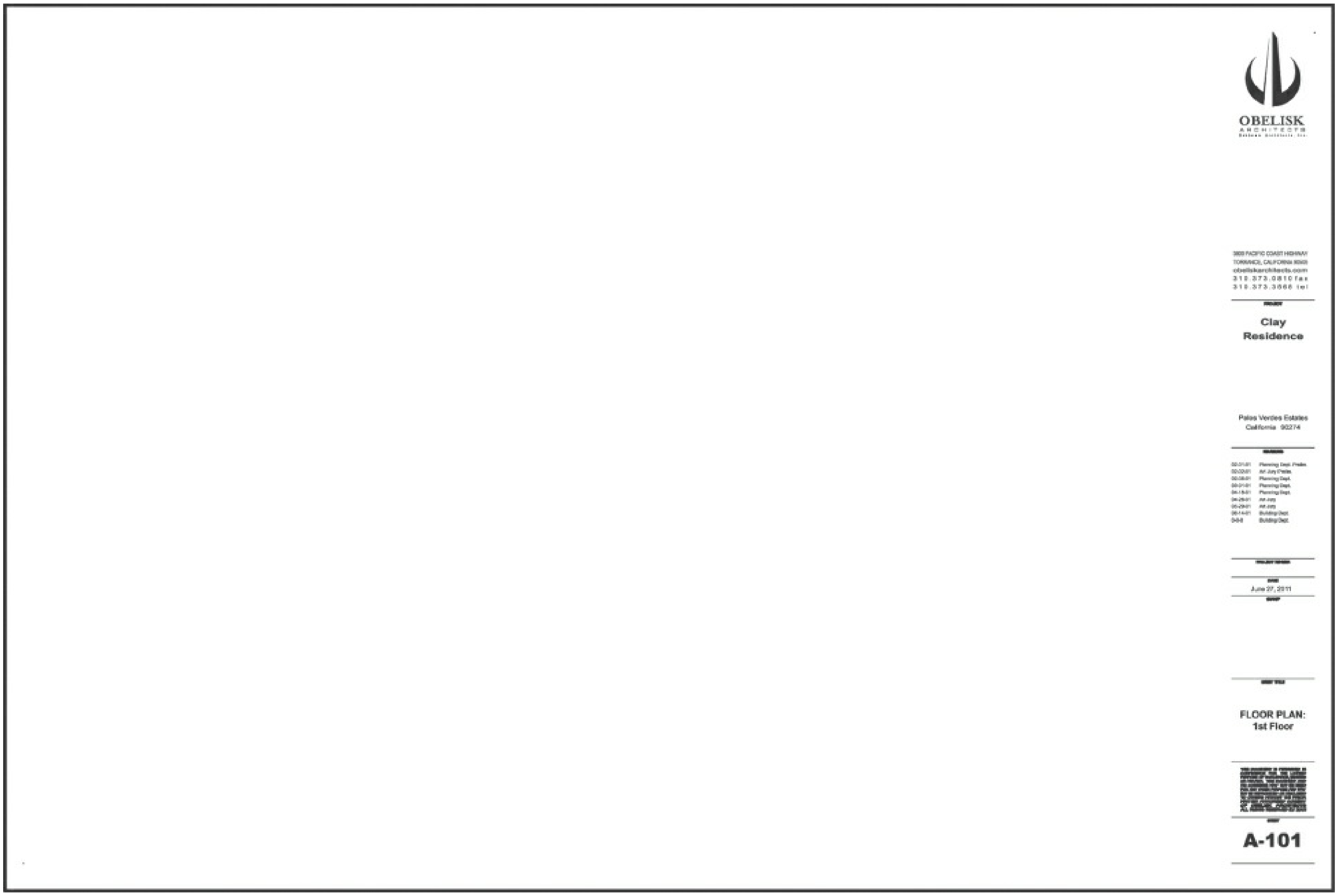


Figure 6.54 XREF: Title block.

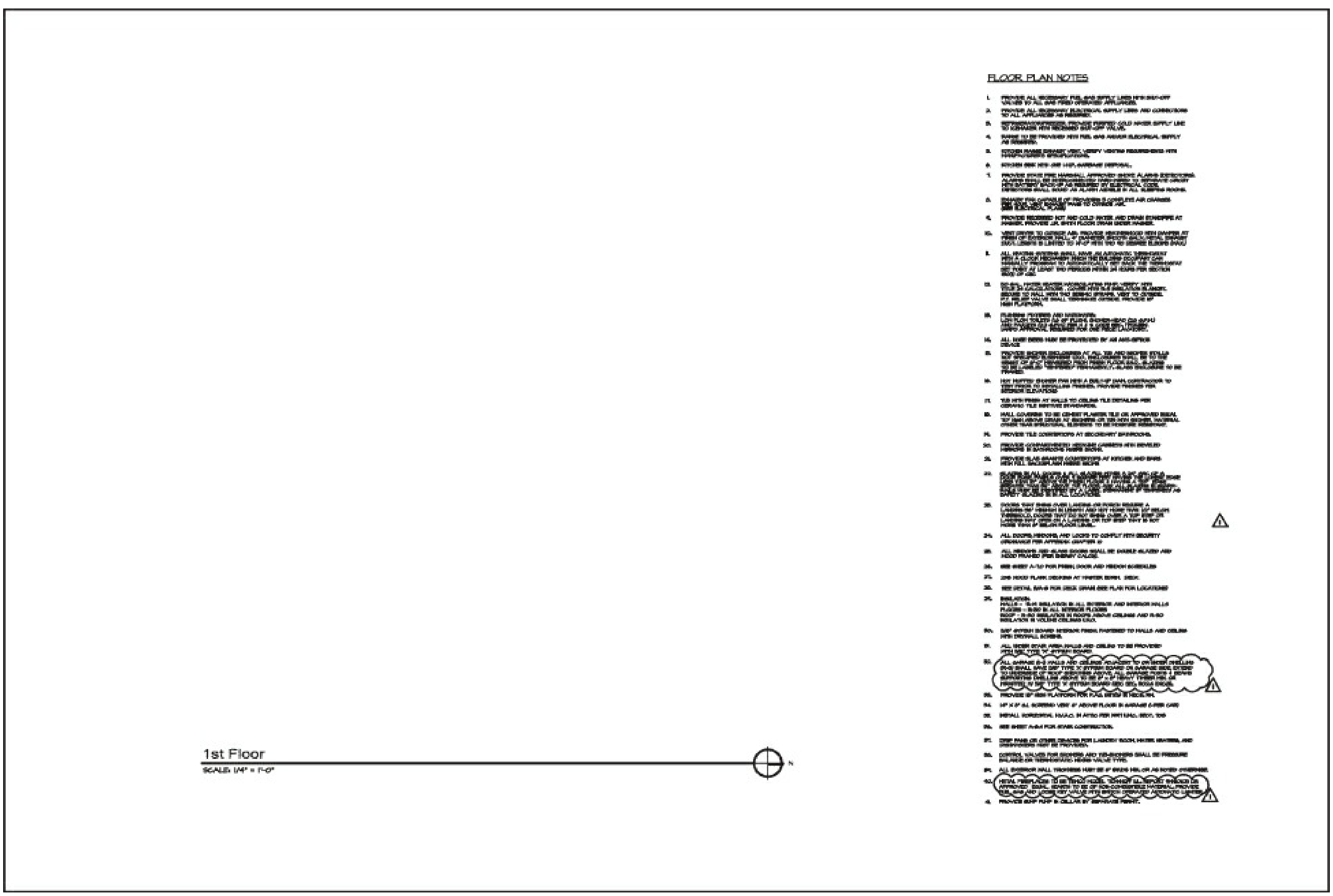


Figure 6.55 Plot sheet: Annotation.

K. As can be seen in Figure 6.44, a set of notes is positioned on the extreme right side. As with details, these may be predrawn or preformatted notes and should be placed on a layer by themselves.

L. Notice the revisions to the notes and in the revision portion of the title block on Figure 6.44. All revisions should be placed on a separate layer.

Delivery or Reproduction

The method of actually printing or plotting a drawing is called the **delivery** or **reproduction** method.

If an engineering copier is used (which reproduces much like a large plain…paper copier), a drafter can paste drawings, notes, and charts onto one large sheet and produce a composite drawing. Even photographs and vendors' literature can be pasted or taped on with page…mending tape. Corrections can be done easily with the use of white correction fluid or a simple cutout.

With CAD, because the entire drawing is electronic, any electronic device can be used as a delivery method, starting with plotters and printers for a hard copy, and moving to PDFs that can be printed out or sent via email.

At one time, there was a cardinal rule in our industry: “Never give the client the originals!” Today, we are essentially giving up our originals by sending electronically based drawings. There are both positives and negatives to sending electronic copies of our documents.

On the positive side,

1. Our consultants get the exact base sheet on which they can compute and draw the framing plans and structural details.
2. For an out…of…stage project, multiple copies can be at another location.
3. Corrections can be made instantly in the field and relayed to the home office.
4. There is no downtime for mail delivery, as was the case with hard copy.

On the negative side,

1. There is a potential for piracy of the drawings.
2. Building departments require wet…copy signatures for permits.
3. Viruses can destroy parts of an image, creating an incorrect set of drawings.
4. Someone can be working on a set of drawings that appears to be the original but is not.

Key Terms

block out

cartooning

delivery

Drafting Room Manual

keynotes

layout

mock…up

Office Standards

page format

procedures

project book

reproduction

sheet layout

standards

PART II
Document Evolution

The information contained in Chapters 7 through 13 is meant to be the foundation of, or the basis (datum) for, all construction documents. For example, the material about floor plans applies to any method of drawing. Whether you are using hand (manual) drafting, computer drafting, or the three-dimensionally oriented Revit, the process is essentially the same. This is true no matter what set of drawings you are producing, from final construction document display to be used for the building department, to two-dimensional image drawings required by the client, contractors, or for bidding (getting estimates).

Chapter 7
SITE ANALYSIS AND SITE DOCUMENTS

INTRODUCTION

Site analysis is among the most important aspects of the preliminary design process. It is the evaluation of an existing or potential site to determine the fulfillment of the clients program. A properly selected site can significantly impact the success of a project. Proper analysis of a site can also take full advantage of the potential it offers.

Site plans locate a building on a specific site in a specific location both vertically in space and laterally. A grading plan assists the architect in the movement of earth in order to accommodate this task. In an ideal situation, the building can be accommodated without significant earth movement, specifically import and export of soil.

The overall goal for the architect is to generate a logical and sensitive development of the land. When the architect is engaged early in the process, they can help the client with the specific selection process. Architects, landscape architects, planners, and others often aid in the process of site selection and analysis and provide this specific service for the client.

Sites are a component of a project that directly affects the cost of a project and construction cost. The specific site may also affect the long list of factors that can help or hurt a specific program. We will outline specific examples in this chapter.

SITE ANALYSIS DEFINED

The purpose of **site analysis** is to determine the best use of the site and find a layout that capitalizes on site attributes to optimize fulfillment of the client's needs while respecting the inherent site conditions. A site analysis is a specific study of the project site and how it supports the program.

Important components of research in site analysis include, but are not limited to, determining:

- Boundaries
- Topography
- Drainage
- Traffic (vehicular, pedestrian, transportation)
- Setbacks
- Climate (rain, sun, snow, wind)
- Lot shape (orientation)
- Site utilities (electric, gas, telephone, TV, water)
- Zoning (easements, covenants)
- Vicinity
- Neighborhood character (positive and negative elements)
- Past, present, and future conditions

Community and Neighborhood Research

Location within a country, county, state, province, and city are all factors in understanding a site. A large view of the site situated in its larger surroundings will aid in developing the site. In addition to the physical aspects of the site, become familiar with the activities that occur in the neighboring area, both positive and negative. These features range from a monthly festival or an annual parade to graffiti incidence and crime patterns.

Understand the site within the context of the neighborhood. This may require a two… to three…block study, in a refinement of the larger…scale study described above. For a larger building, this research might expand to five or six blocks around the site.

Climate Research

Site…specific climate research must include factors such as temperature range, rainfall and snowfall, humidity, prevailing winds, and sun direction, as well as regional concerns such as earthquakes, hurricanes, and tornadoes. All of these factors will affect the approach to site design and layout, although some will be more important than others in any given situation. See Figure 7.1.

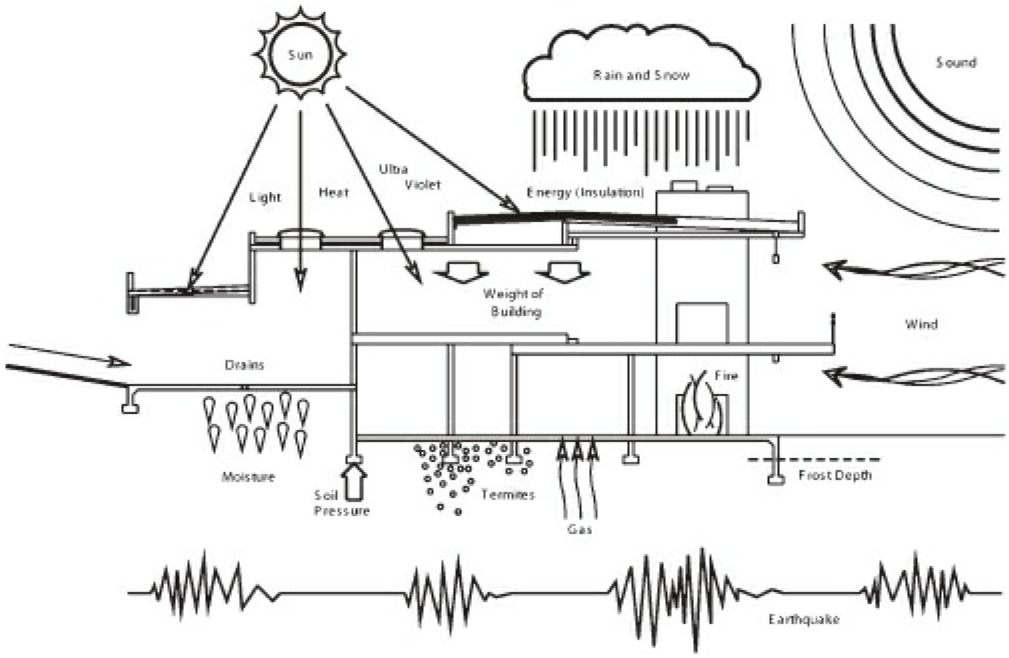


Figure 7.1 Climate impacts.

Site…Specific Research

Each site is identified by a legal description. Some legal descriptions are written according to metes and bounds, but most sites in more developed areas are identified according to plats, subdivision maps, and area maps. Although the format will vary from one municipality to the next, a legal description will typically read something like: Lot **6**, Block **27**, Tract **4289**, as recorded in the Richmond County Map Page 5…69. Once you have this information, you can determine more specific information about the site, such as setbacks, zoning requirements and limitations, development covenants, building area, redevelopment district requirements, and required dedications and easements.

Setbacks are predetermined restrictions that aid in determining the limits on a building footprint. For example, a site may require that the structure not encroach upon a strip of land 20′ in front, 5′ from each side, and 15′ in the rear; these are the required setback dimensions where building is not allowed. A height limitation will determine the maximum allowable height of a structure. In most cases, there are also limits on the maximum allowable area or square footage of a building. A **building footprint** is the total area of a building that covers the parcel. This footprint can be imagined as the dry outline that a rainfall will not touch as a result of the shape of the building on a parcel. Often a **floor area ratio (FAR)**, or the gross area footage, is established so that the site cannot be completely covered from setback to setback. For example, a 1.5 FAR would limit an architect to a building area that is 1.5 times the total lot area.

Zoning—a municipal system of controlling what activities and structures are permitted on a piece of property—is determined by a governmental agency that has a primary purpose of public protection, implemented by rules harmonizing allowable land uses with owners' desires and the highest and best use of a site. This is what keeps high…rise office buildings and industrial production facilities from being built on a block of two…story residences. **Dedications** are portions of a site identified by the governing agency as a

required contribution of land for an express public purpose. Most common is a dedication for a new road or a road expansion, which can vary in scale from a couple of feet to a strip 10 or 20 feet wide. Another example is a required greenbelt area. Often, site owners are not compensated for a dedication; it is considered a cost of development. A site may also be subject to *easements*, which are portions of the property that others have the right or permission to use in some way even though the owner retains title to the land; most common are utility right…of…way easements.

Many city and county agencies have established **redevelopment districts** within their jurisdictions. Land use in redevelopment districts must, for various reasons, follow a different set of use and building guidelines to achieve an overarching, specific public goal. In many cases, these guidelines are more stringent than zoning requirements for other areas, but in some cases they may be less restrictive.

Utility Research

In some areas, such as Manhattan, determining the availability of electricity, gas, sewer, water, telephone, and cable television may be as simple as visiting a public works or engineering counter. In other areas, such as Wyoming, finding this information may be much more involved, and one may have limited utility options. In large cities, most utilities are immediately available, and typically are routed underground in the street or under sidewalks. In the Wyoming countryside, each site owner may have to have a well drilled to access fresh water and bear the cost of bringing in the lines for electrical and telephone service; natural gas, sewer, and cable TV may not even be options. Obviously, these considerations weigh heavily on the possible uses of the site and the type of structure. To fully understand the utilities of a specific site, one must also determine the depth, pipe diameter, pipe material, and pressure available. See Figure 7.2.

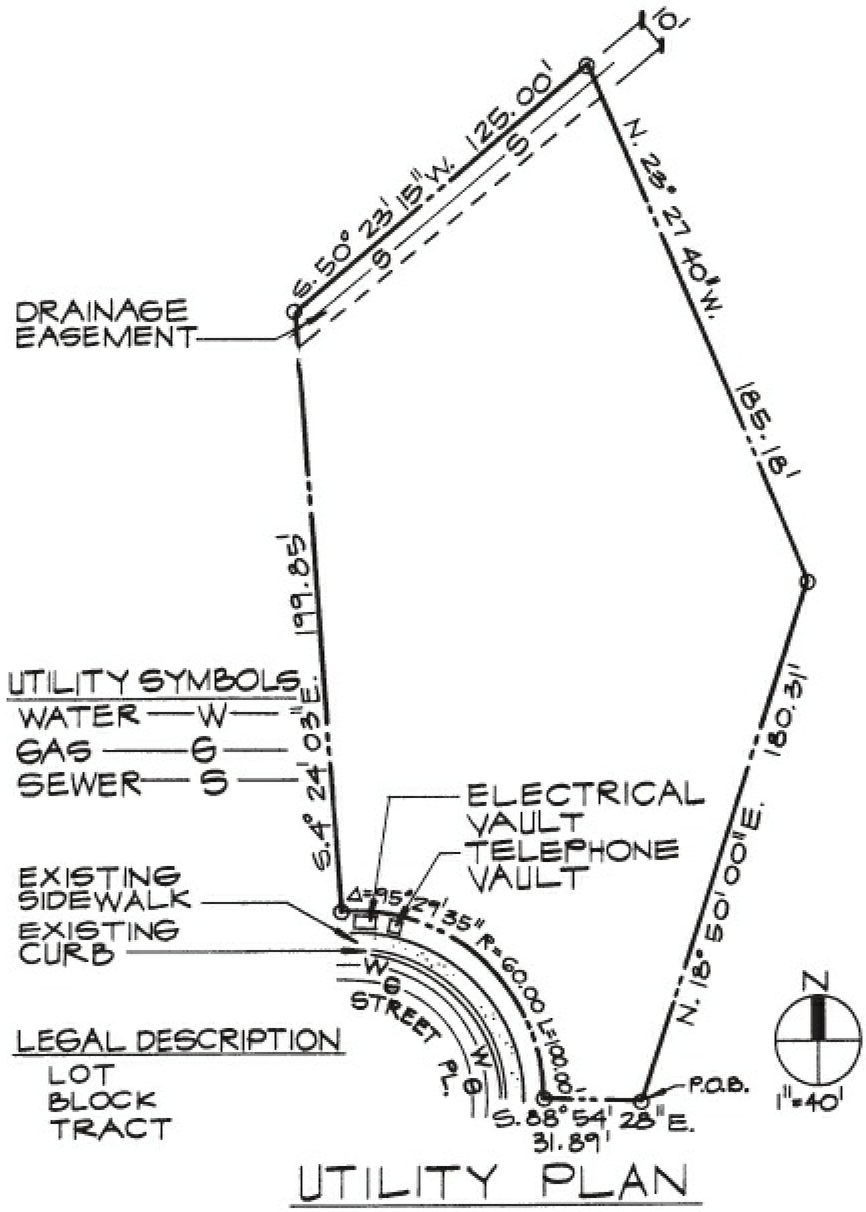


Figure 7.2 Utilities.

Circulation Research

Understanding how people will approach or access a site will affect your design for the site. Are there bus and train stops or metro stations near the site? Do service trucks or fire trucks figure prominently in the traffic pattern study? Perhaps there is an elementary school nearby, or vehicles can make a right turn only. Consider future development as well: Is there an electric trolley stop planned near the site or a future police or fire station adjacent to the site?

Sensory Research

Document and observe significant views to and from the site, both positive and negative. Understand the impact of building and window placement in relation to those views. Often, noise, such as from vehicles, trucks, trains, buses, or airplanes, can affect site conditions. Even smells should be taken into account: it takes only one design of a building downwind from a dairy farm or paper mill for the designer to learn never to

overlook the “scentscape” of a site again! See Figure 7.3.

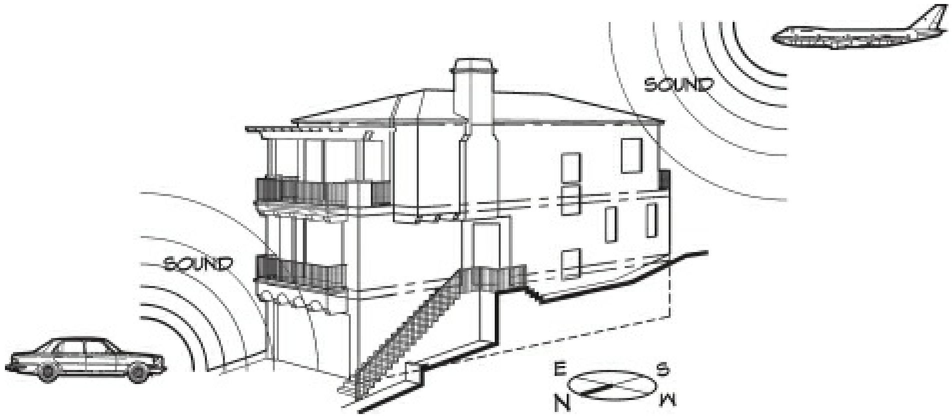


Figure 7.3 Tracking impacts.

Features

Significant natural features often include the views discussed earlier, but natural elements such as a winter spring or creek, a rock outcropping, or a vertical bluff can strongly influence the layout of a site. See Figure 7.4.

Figure 7.4 Natural features.

The three natural elements that perhaps will most affect a site plan are the **existing contours**, or the slope of the site; the **soil type** and **bearing capacity** (how the soil supports the structure of the building); and the **geology**, the nature of the earth's structure beneath the soil elements. Geological concerns also include things like archeological/prehistoric sites that might affect the future building foundation or even location. This is discussed further in this chapter, in detail.

In some regions, native and preexisting trees are protected, whether by law or by covenant. In many cities in California, for example, the California live oak, walnut, and others are in this category and may not be removed or damaged.

Man_made features that are on a site or adjacent to the site should be documented as well. Elements such as existing structures, buildings, walls, curbs, gutters, sidewalks, power poles, light poles, and fire hydrants are often difficult to move or relocate. Even if they can be moved, it is usually very expensive to do so; alternatives should be explored before deciding to relocate an existing feature.

On occasion, man…made features will limit access to a site. (Perhaps there is a center divide on a street, with no left turn lane or median cut to allow vehicles into your site.) Document and record all of these features, as they will further shape the site plan.

SITE ANALYSIS APPLIED

Implementing Site Analysis

Accumulation of research on a specific site will allow the architect to establish a series of important supporting documents, some of which will require the consultation of a civil engineer. Many drawings may be needed to further develop the analysis of the site, including:

- Vicinity plan
- Location plan
- Plat map
- Topographic map
- Site plan/plot plan
- Grading plan
- Drainage plan
- Erosion control plan—storm water system mitigation plan (SWSMP)
- Utility plan
- Circulation plan
- Landscape/Irrigation plan

Not all of these drawings are created for every job, but the more complex jobs may require all of them.

Vicinity Map

A **vicinity map** provides an overall view of the region around the specific site to better introduce the surrounding neighborhood or district. Often, this map will be provided on the cover sheet of a set of working drawings. See Figure 7.5.

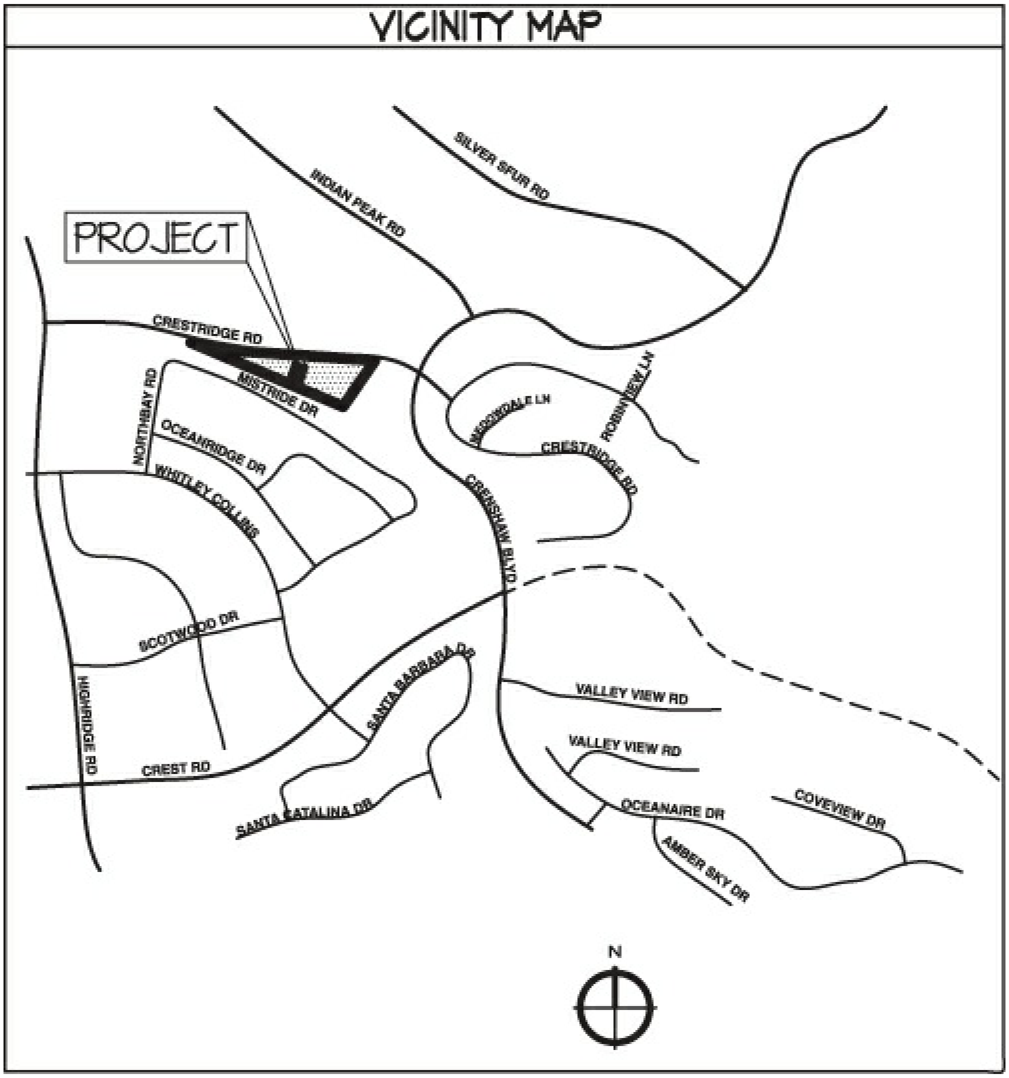


Figure 7.5 Vicinity map.

Location Plan

A **location plan** helps the viewer see the proposed project in relation to the specific area where the work is to be accomplished. This is particularly important on large…scale projects such as campuses or warehouse facilities. See Figure 7.6.

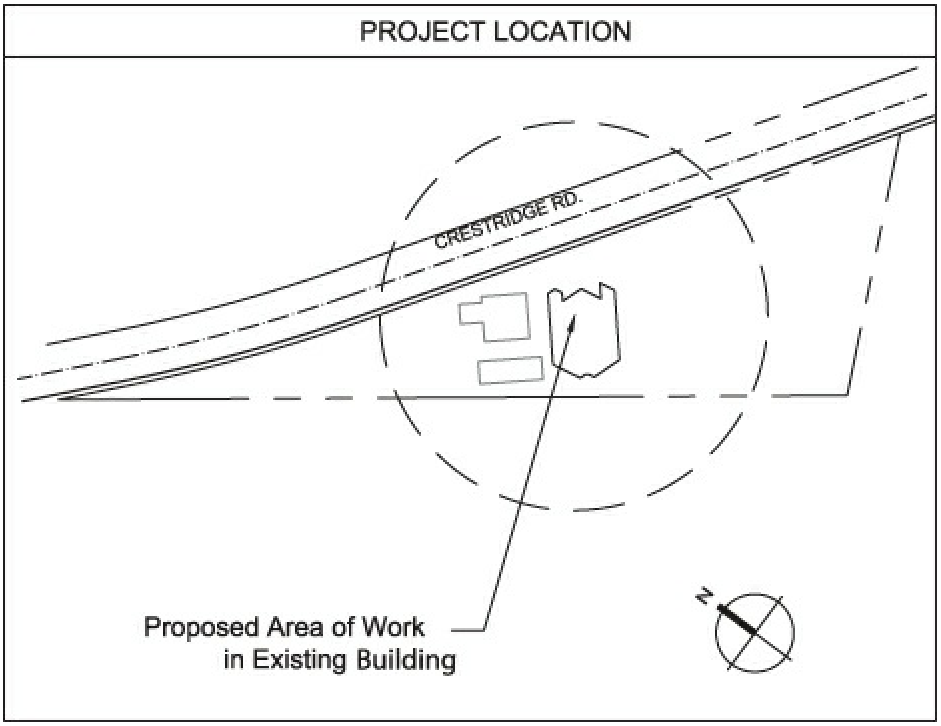


Figure 7.6 Location plan (map).

Plat Map

The site plan is developed in stages, each dealing with new technical information and design solutions. The first step in site plan development is the **plat map**. This map, normally furnished by a civil engineer, is a land plan that delineates the property lines with their bearings, dimensions, streets, and existing easements. The information from the plat map forms the basis of all future site development. The property line bearings are described by degrees, minutes, and seconds; the property line dimensions are noted in feet and decimals. These are termed the **metes and bounds**. See Figure 7.7.

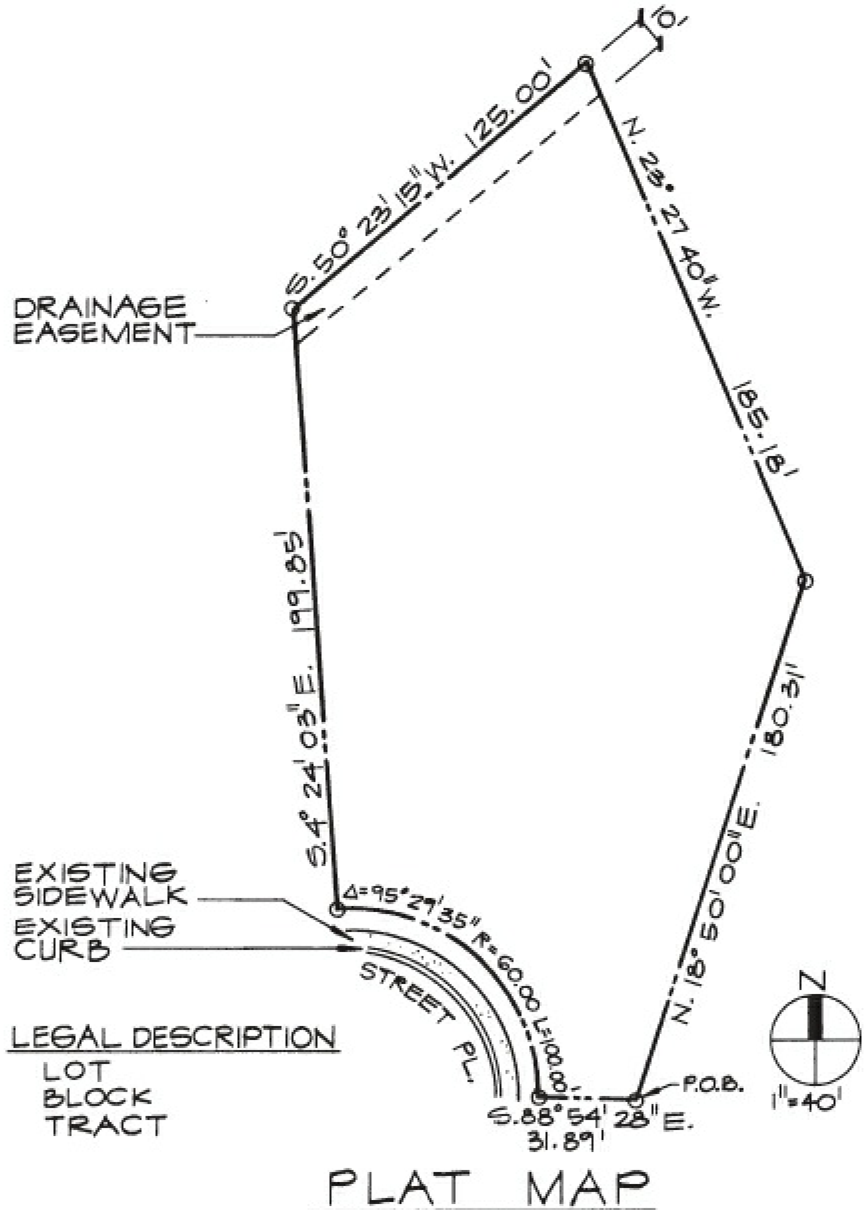


Figure 7.7 Plat map.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Even when the architect is furnished with only a written description of the metes and bounds of the plat map, a plat map can still be derived from this information. Lot lines are laid out by polar **coordinates**; that is, each line is described by its length plus the angle relative to true north or south. This is accomplished by the use of compass direction, degrees, minutes, and seconds. A **lot line** may read N 6° 49′ 29″ W (this describes the lot line as running north 6 degrees 49 minutes, 29 seconds westerly). See Figure 7.8. In some U.S. counties, a boundary description can be retrieved via the Internet from the county in which the plat is located.

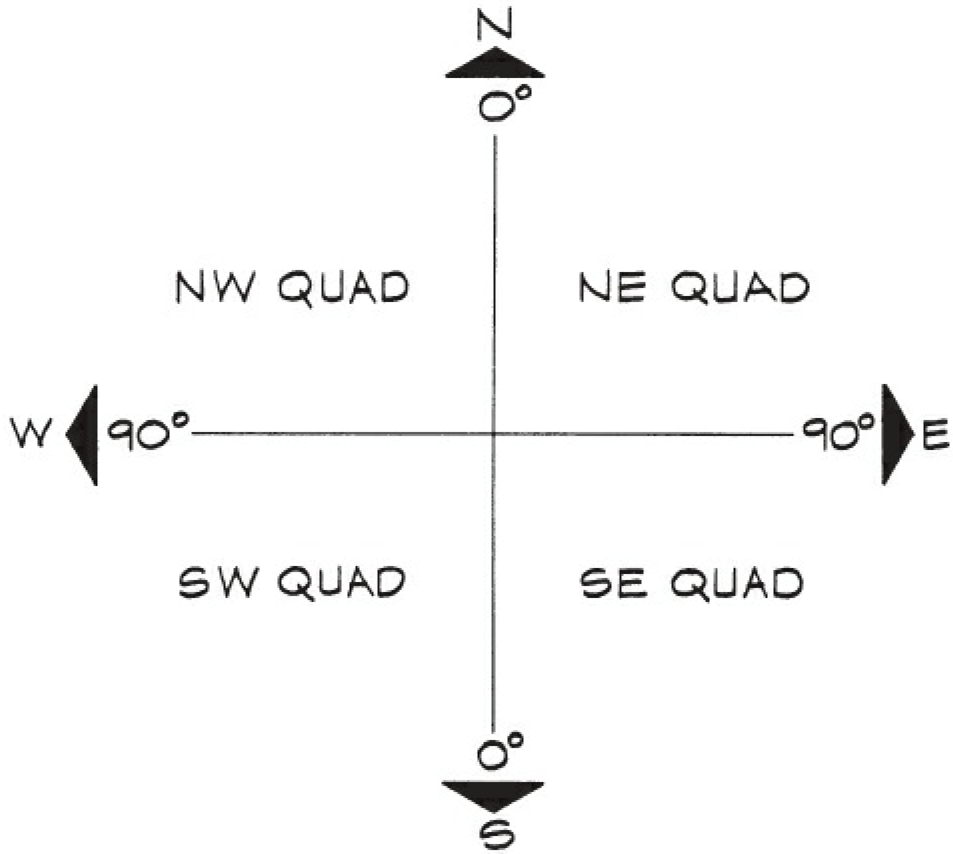


Figure 7.8 Compass quadrants.

Drawing a Plat Map

Figure 7.9A shows a plat map with the given lot lines, **bearings**, and dimensions. To lay out this map graphically, start at the point labeled **point of beginning (P.O.B.)**. From the P.O.B., you can delineate the lot line in the northeast quadrant with the given dimension. See Figure 7.9B. The next bearing falls in the northwest quadrant, which is illustrated by superimposing a compass at the lot line intersection. See Figure 7.9C. You can delineate the remaining lot lines with their bearings and dimensions in the same way, eventually closing at the P.O.B. See Figures 7.9D, 7.9E, and 7.9 F. For a plat map layout, accuracy is critical; thus, it is preferable to accomplish this task on a computer.

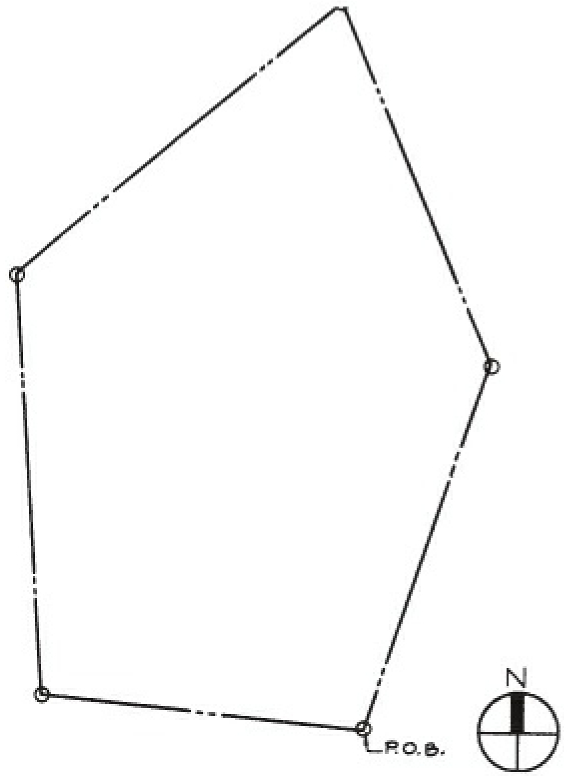


Figure 7.9A Point of beginning.

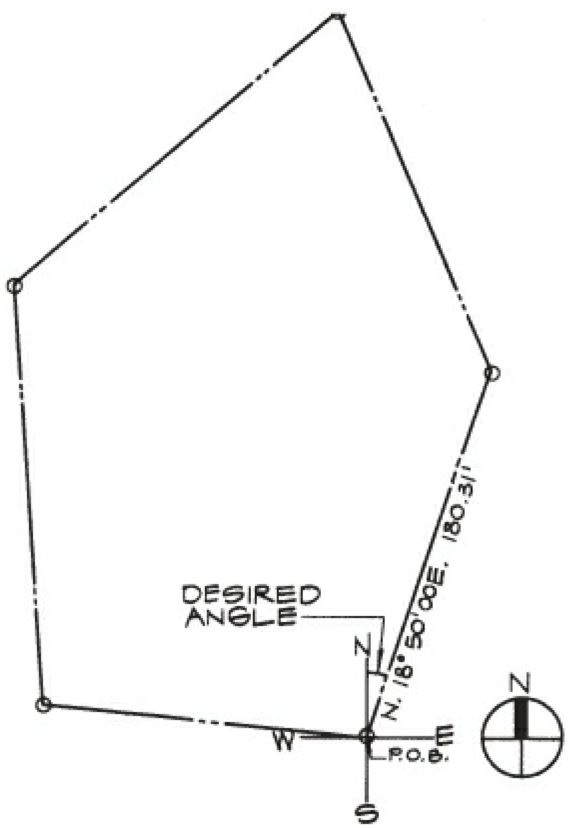


Figure 7.9B Point of beginning and first angle.

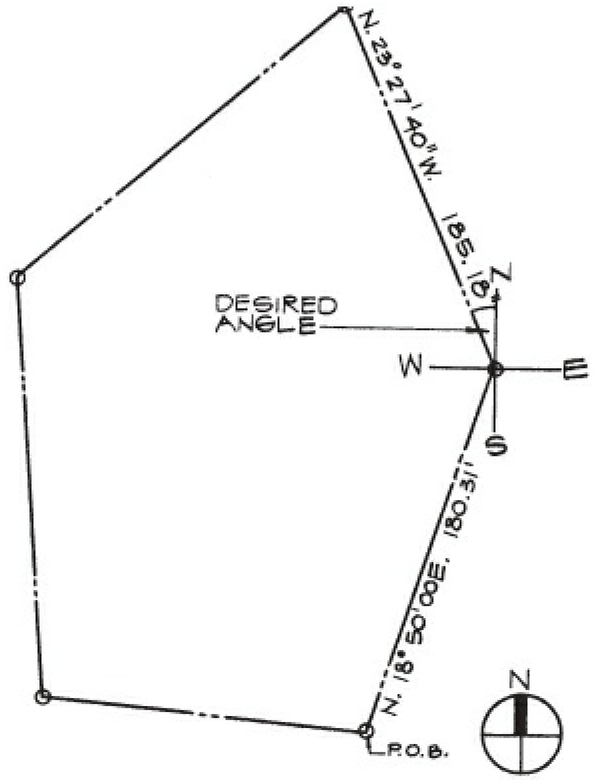


Figure 7.9C Point of beginning and second angle.

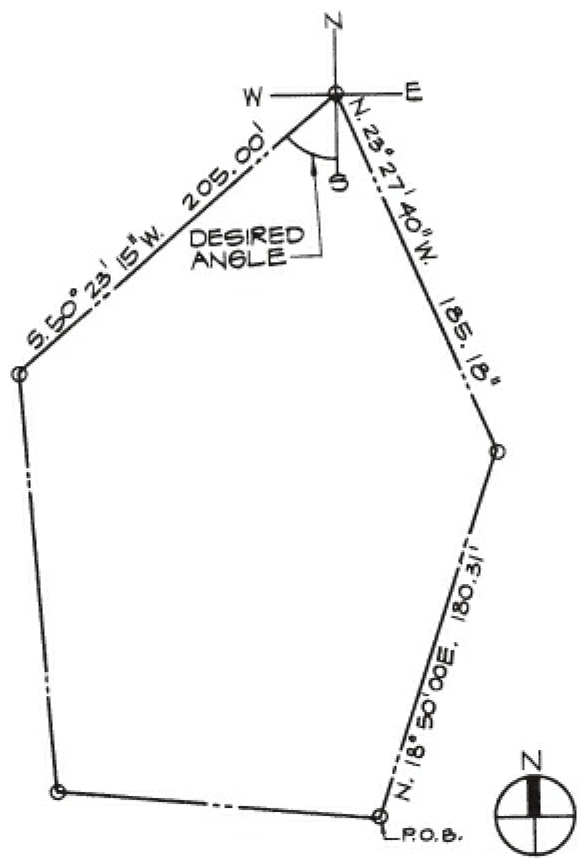


Figure 7.9D Point of beginning and third angle.

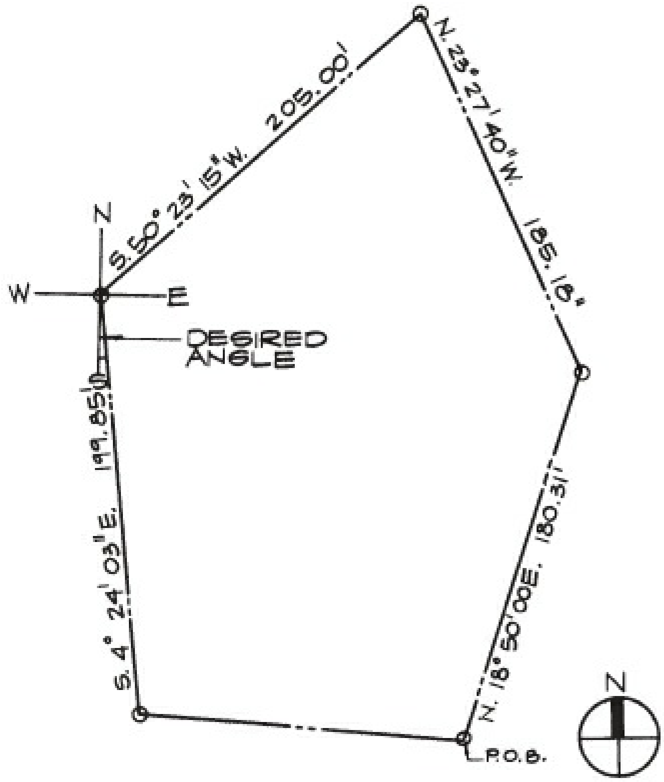


Figure 7.9E Point of beginning and fourth angle.

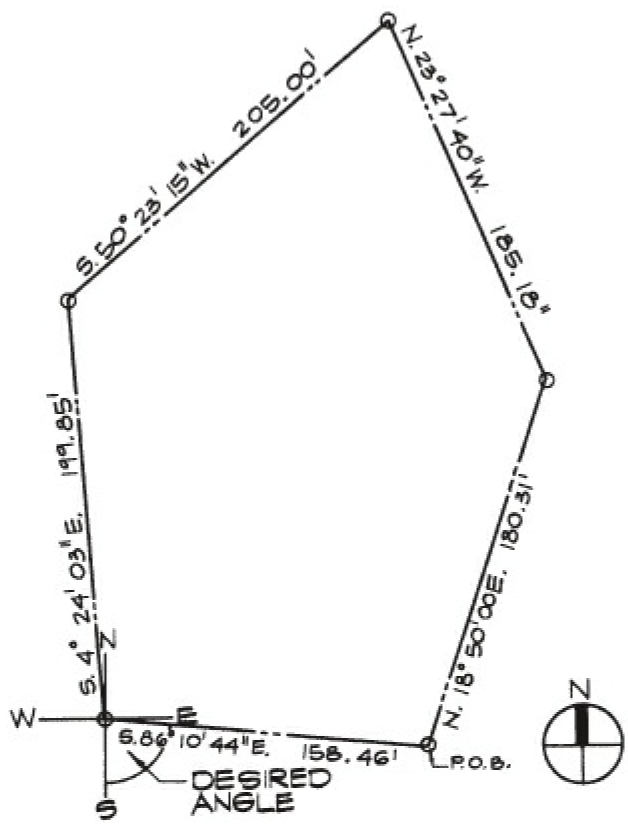
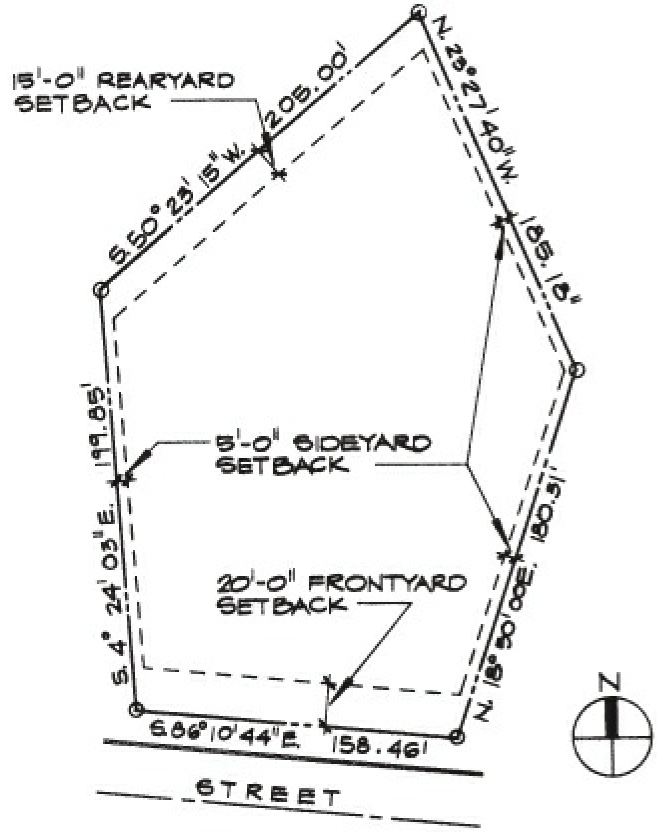
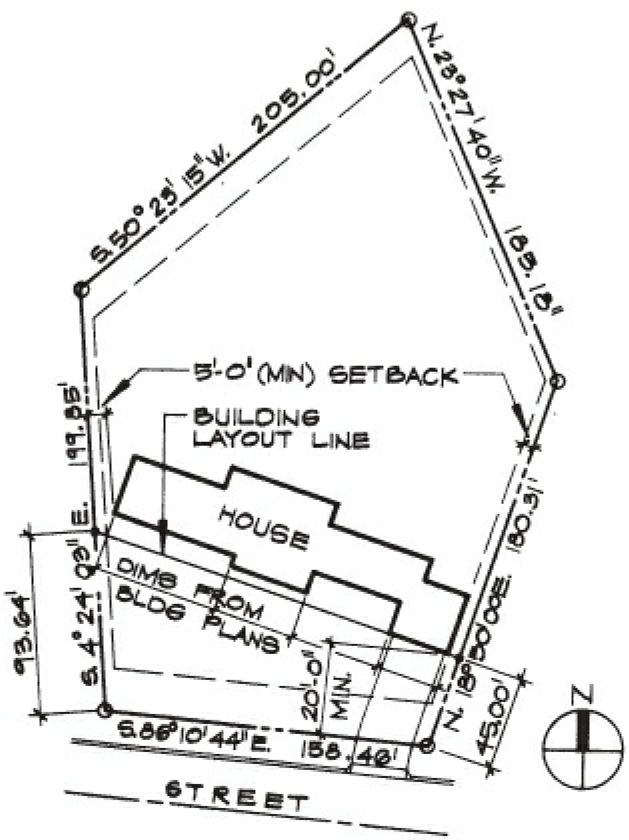


Figure 7.9F Point of beginning and fifth angle.



[Figure 7.9G](#) Site plan with building setbacks.



[Figure 7.9H](#) Site plan with building location.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

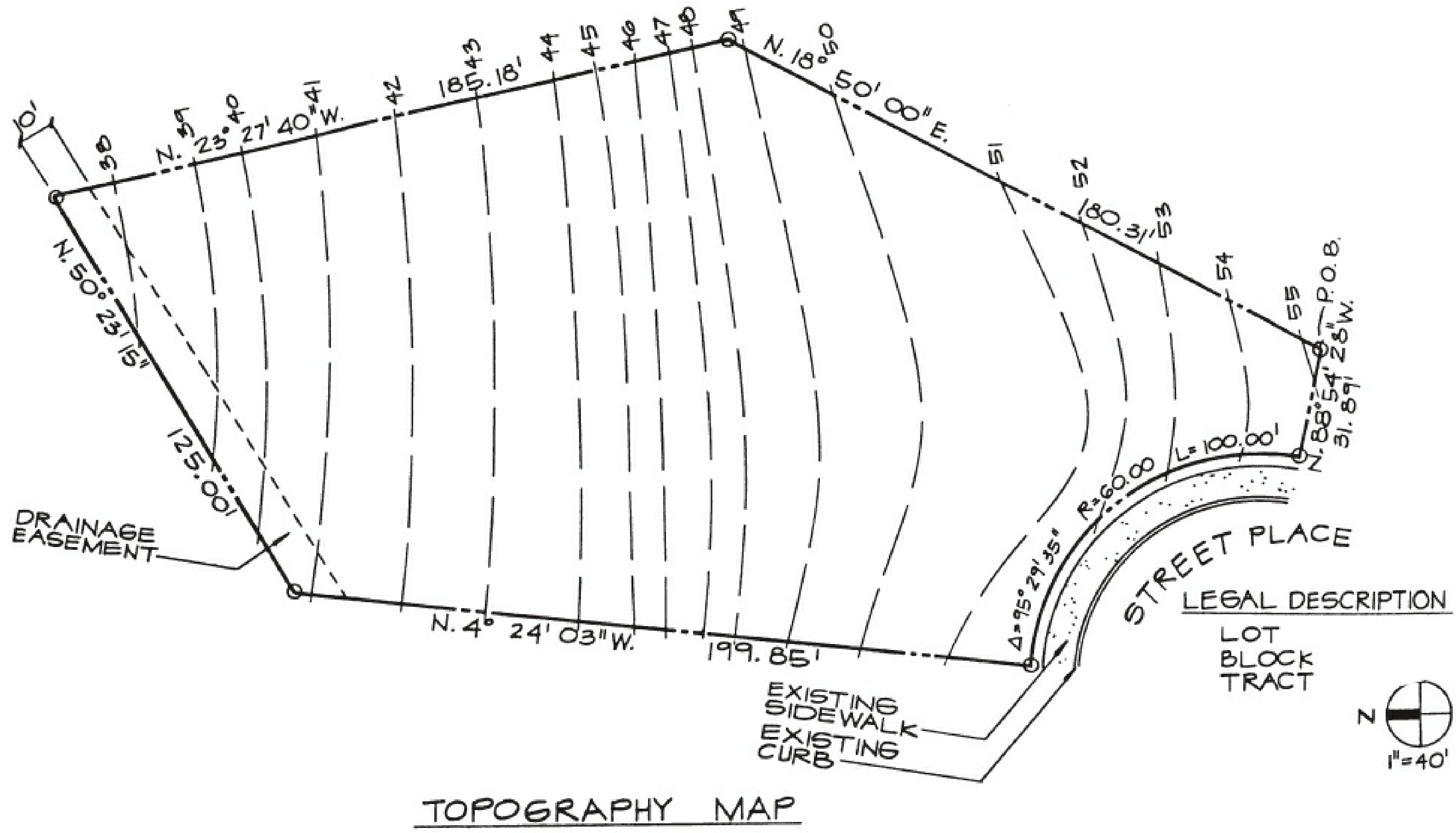
With the completion of the plat map layout, a specific plot of ground has been established. The boundary of a plat will also influence the development of the property.

For the purpose of the architectural construction drawings, this portion of the drawings is called the **site plan** or **plot plan**. This drawing can now be utilized to determine the city… required setbacks required for aesthetics or life safety. In Figure 7.9G, the front yard, side yard, and rear yard setbacks are illustrated for the purpose of defining the governing building setback locations.

The next step in site plan development is to provide a dimensional layout for a proposed building. One method, as shown in Figure 7.9H, is to provide a dimension along the west and east property lines. Starting from the front property line, establish a line parallel with the front of the building, to determine the angle of the front of the house in relation to the front property line. In addition, from this parallel line, dimensional **offsets** of the building can be established. Note also in Figure 7.9H that all required yard setbacks will be maintained without encroachments.

Function of a Topography Map

For most projects, the architect adjusts the existing contours of the site to satisfy the building design and site improvement requirements. **Finish grading** is the process of adjusting existing contours so that they are in the desired position for the final stage of the site improvement process. The architect needs a topography or topographical map to study any slope conditions that may influence the design process. Usually, a civil engineer prepares this map and shows, in drawing form, the existing **contour lines** and their accompanying numerical elevations. Commonly, these contour lines are illustrated by a type of broken line. The **topography map** is actually a plat map, and its broken lines and numbers indicate the grades, elevations, and contours of the site. See Figure 7.10.



[**Figure 7.10**](#) Topography map.

A topography map can appear complex. However, a **cross_section** or a cutaway view through any portion of the site can make the site conditions clearer; this will also be valuable for the finish grading. See [Figure 7.11](#). The rise or fall of the contours will represent the change of elevation, from the front or rear of the site.

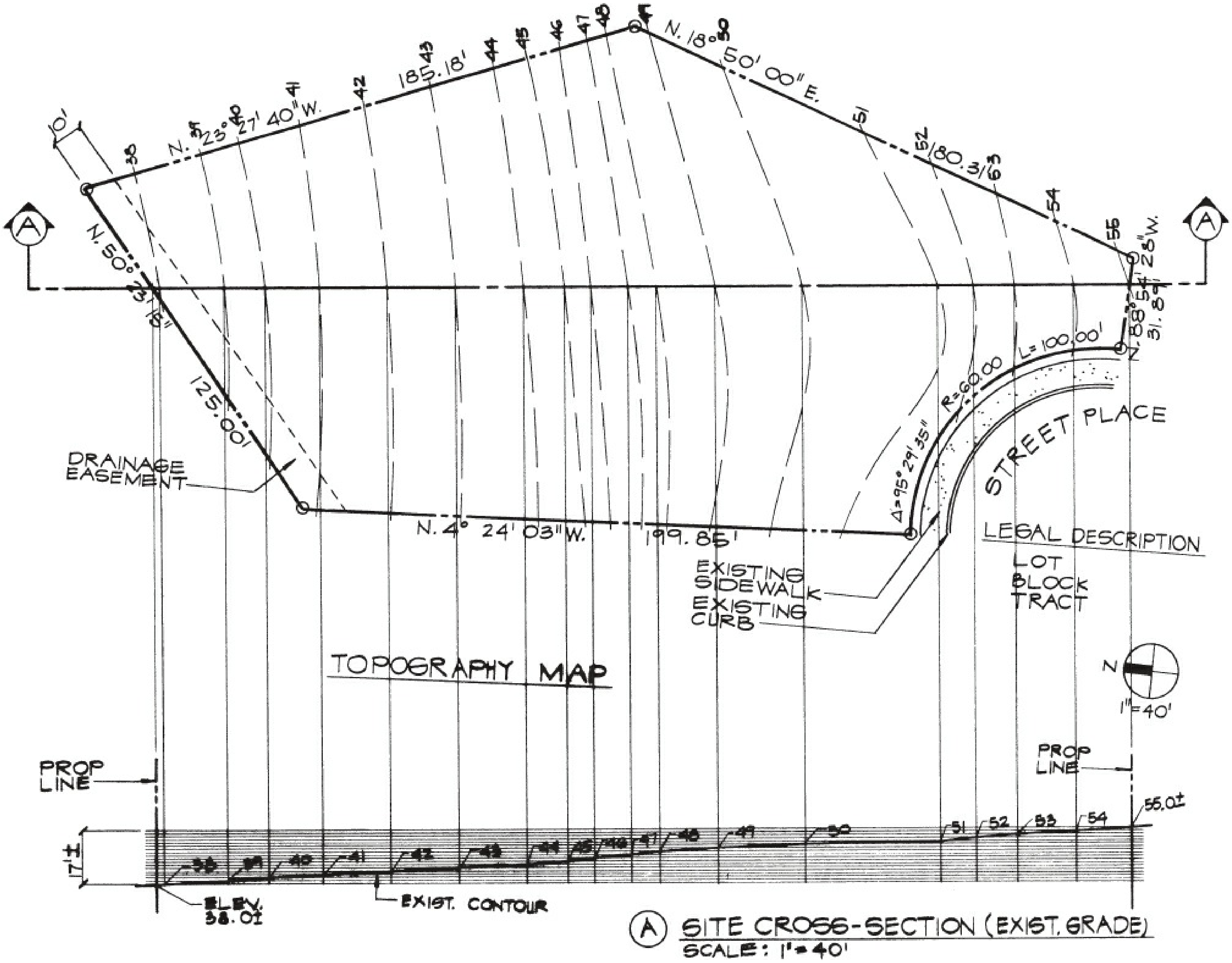


Figure 7.11 Topography map with section lines and cross‐section.

To make a cross‐section, draw a line on the topography map at the desired location. This is called the **section line**. Next, draw a series of horizontal lines, using the same scale as the topography map and spacing equal to the grade elevation changes on the topography map. These lines represent the vertical elevation of the grade. Project each point of grade change to the appropriate elevation line. Now connect the series of grade points to establish an accurate section and profile through that portion of the site. In many cases, multiple cross‐sections are required to better understand the existing or proposed grade.

SOILS AND GEOLOGY MAP

Soils investigations evaluate soil conditions such as type of soil, moisture content, expansion coefficient, and soil bearing pressure. **Geological investigations** evaluate existing geological conditions such as fault lines and bedding planes, as well as potential geological hazards.

Field investigations may include test borings at various locations on the site. These drillings are then plotted on a plat map, with an assigned test boring identification and a written or graphic report. This report provides findings from the laboratory analysis of boring samples under various conditions. See Figure 7.12.

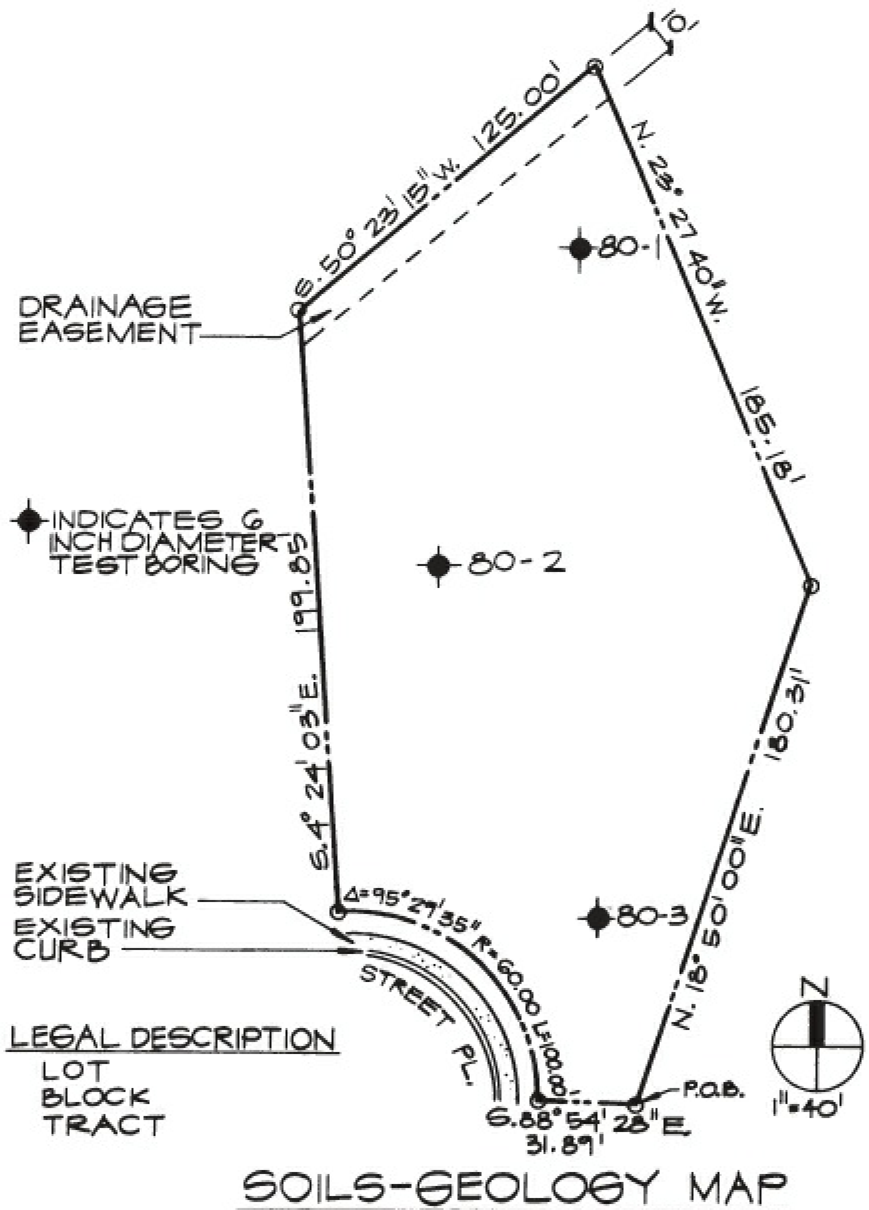


Figure 7.12 Soils…geology map.

When there are concerns about geological instability and soil, the particular problem areas may be plotted on a **soils and geology map** for consideration in the design process. Figure 7.12 shows a plat map with each test boring identified. This map becomes a part of the soils and geological report. Borings are done close to the location of the proposed work established by the architect or the area of structural concern. Figure 7.13 shows a **boring log** in graphic form. Notice the different types of information presented in the sample boring log. Figure 7.14 shows a geological cross…section.

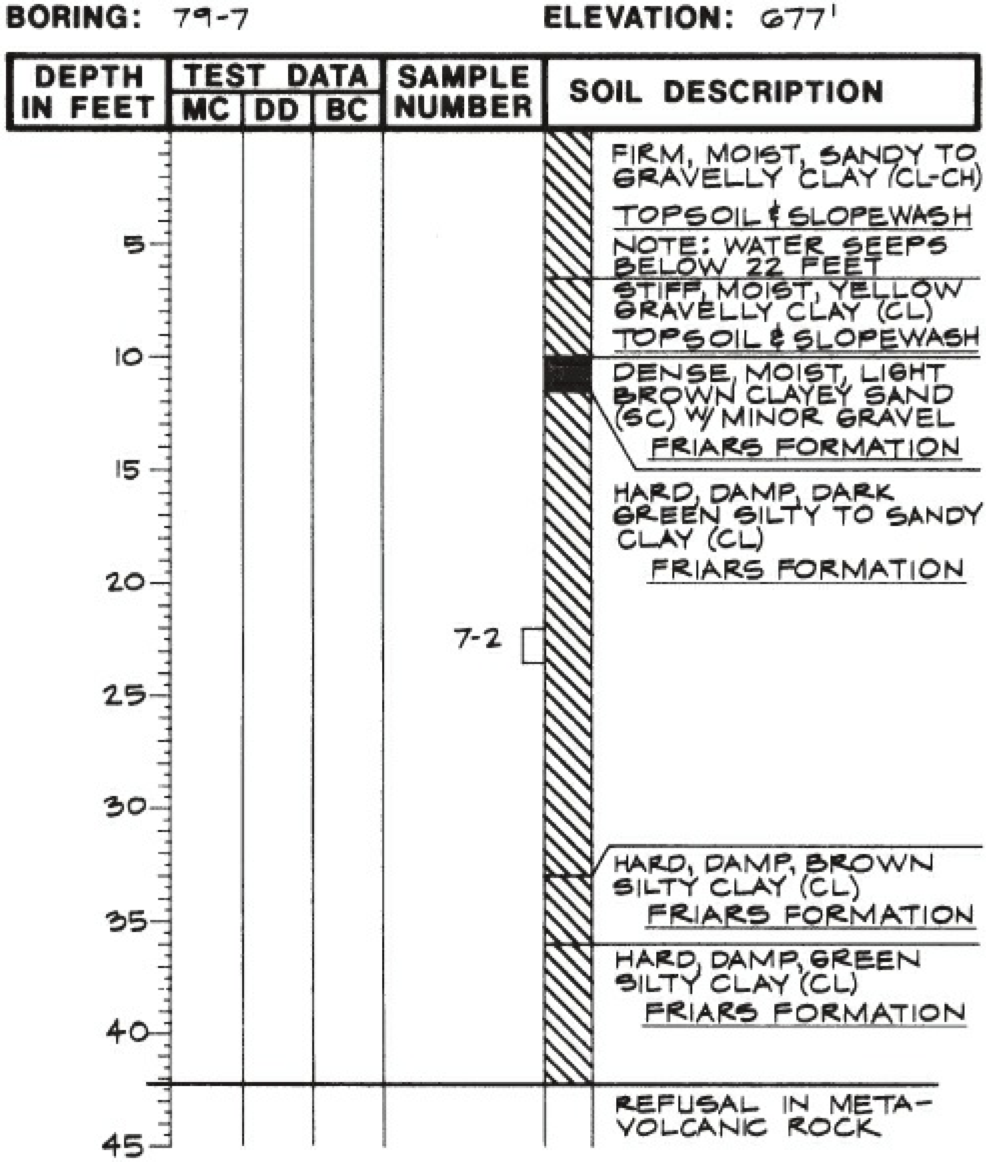


Figure 7.13 Example of a boring log.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

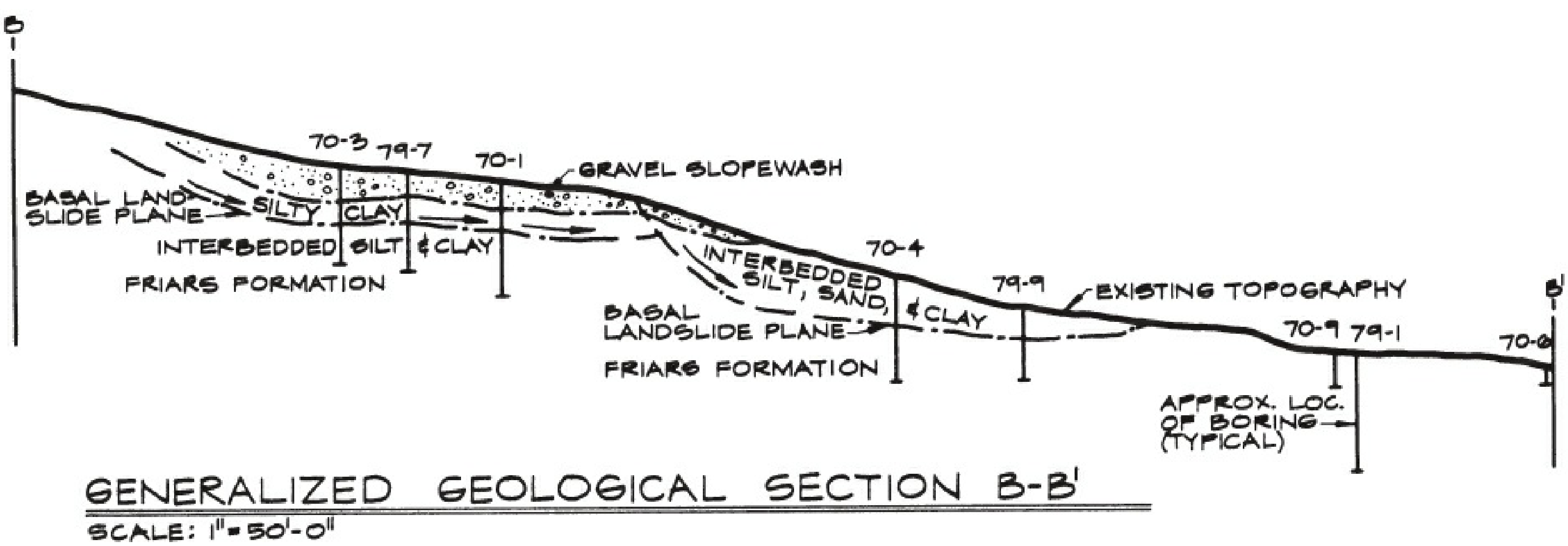


Figure 7.14 Geological cross‐section.

Architects are not significantly involved in preparing drawings for geology and soils

information other than locating the proposed work on a site plan and perhaps a site section. However, it is important to have some understanding of their content and representation in order to understand how it may affect design. It will most directly affect the foundation design, system, and size of foundation.

SITE PLAN

Drawing a Site Plan

When drawing a site plan, the easiest way to start is to call your civil engineer and ask for a digital copy of the site topography for the project. This drawing becomes the base drawing on which various layers are drawn, such as setbacks, building location, dimensions, noting, and so on. See Figure 7.15.

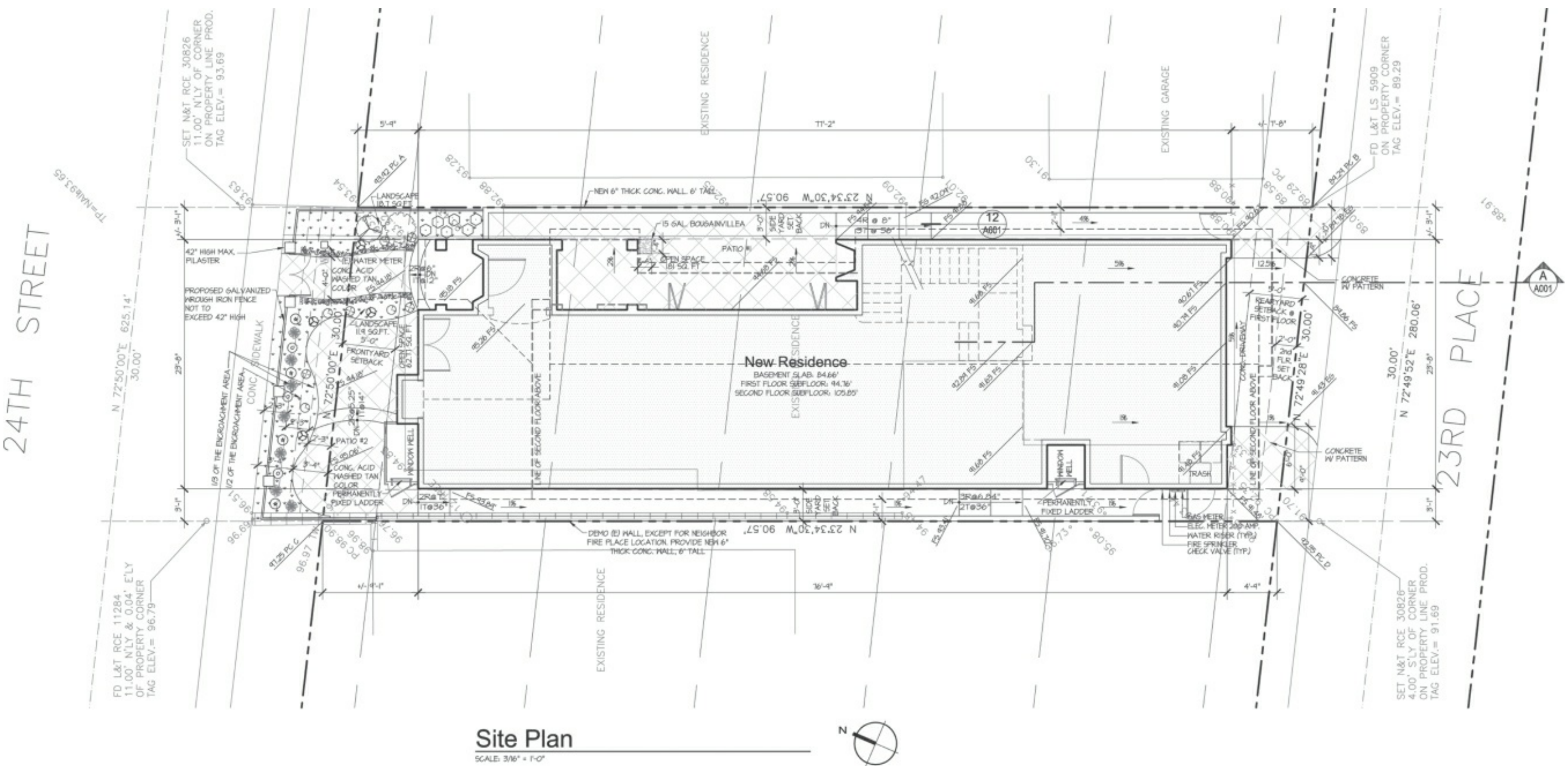


Figure 7.15 Site layout (site plan).

(Courtesy of Mr. & Mrs. Givens.)

If a drawing is available as a hard copy but not digitally, you can scan the drawing into the computer, and then size and scale it. If you are fortunate enough to have a building information modeling (BIM) program to draw site plans, then it's just a matter of following the procedure outlined in Figure 7.9A through F.

In most CAD programs the drafter must adjust his or her thinking to accommodate the computer. For example, in the majority of instances, the computer has been programmed to view the east compass bearing as 0°, north as 90°, west as 180°, and south as 270°. If you need to draw a property line N 18° 50′ 00″ E, you must understand that line will be drawn in the wrong location if you do not adjust the computer orientation. For the purpose of giving the computer the proper command, you must subtract 18° 50′ from 90°

and instruct the computer to draw a line 71° 10′. Let us continue drawing this lot (developed on Figure 7.9) and construct the second line of 23° 27′ 40″. Because north is 90°, we must add 27° 40′ 40″ to 90°, giving us 113° 27″ 40′, and relay this instruction to the computer. Understand that the computer bearing 0° is the east direction on a compass. It may prove to be simpler to develop the entire site boundary without correcting angles until you have closed back to the P.O.B., and then rotate the drawing 90° to the correct orientation.

A final note: You will find no key for degree unless it has been programmed into the computer. Often, you can type in % % d to get the degree symbol. Once the final line is drawn, you must ensure that the polygon is totally closed.

BIM Site Plan

The first component to introduce is the existing topography or contouring of the building site. BIM programs allow you to create a three…dimensional site plan including the shape of the slope of the property. This can be accomplished by importing a topography map produced by the civil engineer, or you can develop it by selecting points around the footprint of the ground…floor plan. Once topography is established, modifying a "topo" is a matter of editing the data or shape. You can add trees, shrubs, plantings, and sod by selecting the appropriate materials from the library and placing them. See Figure 7.16. At any stage, additional elements, such as property lines, setbacks, utilities, and dimensions, can be added to the site plan.

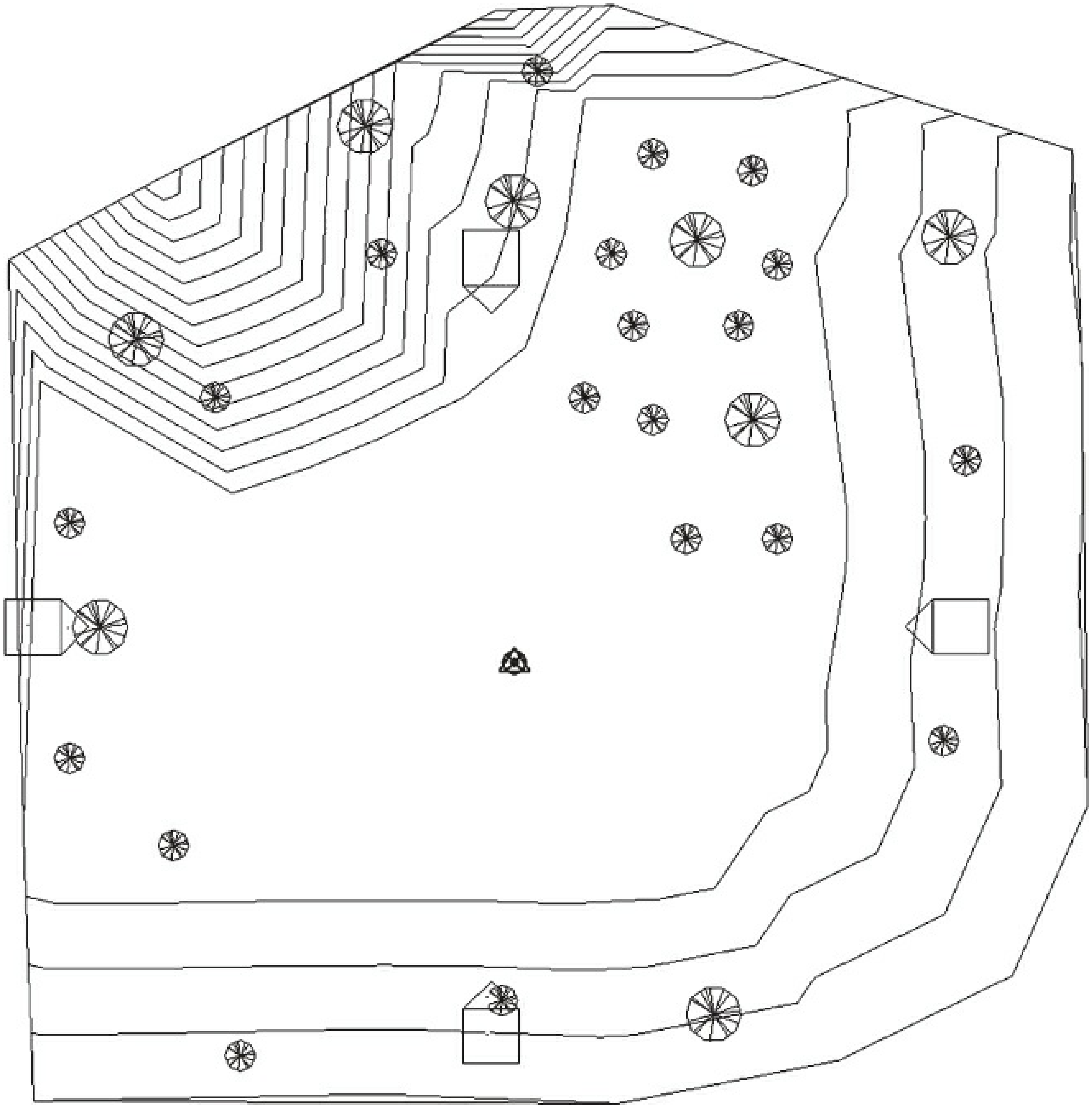


Figure 7.16 BIM site plan.

For most building designs, cutting and filling grade areas are required to be calculated. A shortfall of BIM, albeit one that is easily overcome, is that BIM will not recall the original topography. It is necessary to make a copy of the completed site and name it something different to keep track of the original data. Once this is done, cut and fill can be determined in reference to the original topography. See Figure 7.17.

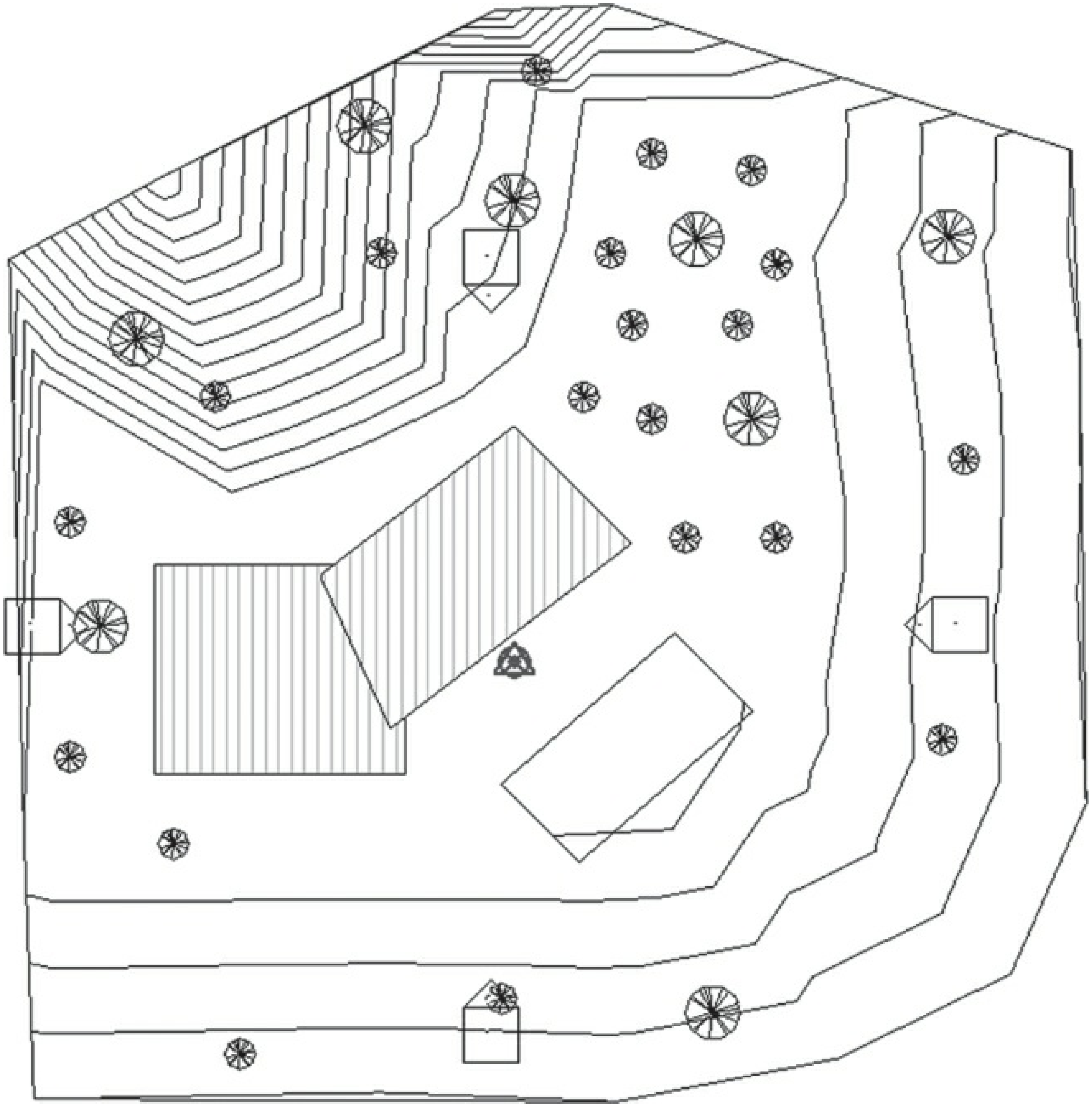


Figure 7.17 BIM developed site.

Architects may choose to create a project with a north orientation, but when modeling in BIM true north must be accounted for so that solar studies can be accurately depicted and proper representation of shades and shadows can be viewed. In addition, the vertical height relative to sea level will be required (default set to 0′ at sea level). Without these two critical adjustments, a site plan may be valid but models, shades, and shadow will not. See Figure 7.18.

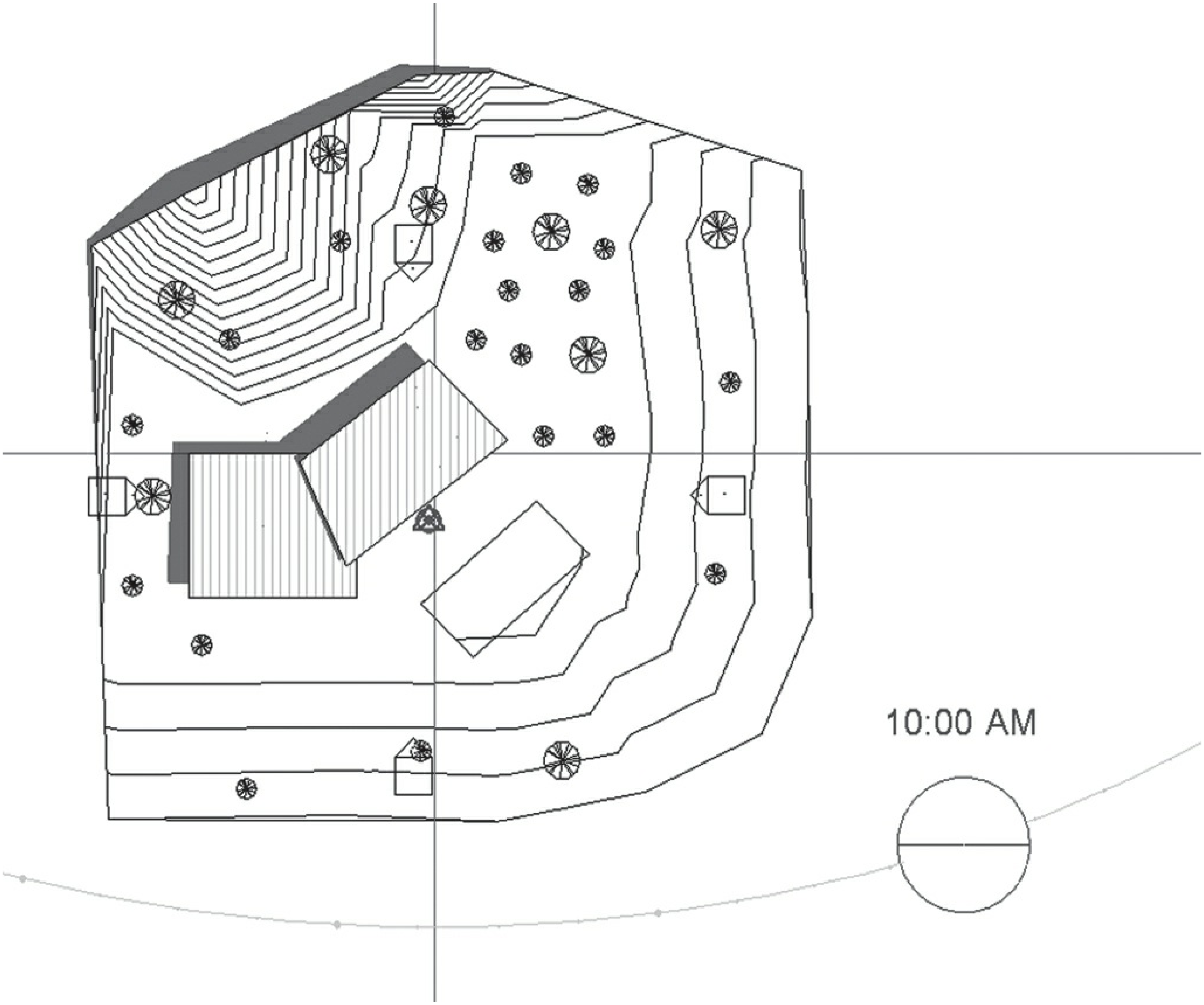


Figure 7.18 BIM shades and shadows.

Procedural Stages for Site Plan Development

Stage I. The architect requests a digital drawing of the site plan illustrating the property lines, existing grade contours, and any major physical features such as trees, utility poles, or any other feature that may dictate or influence the site plan process. This digital drawing is provided by a civil engineer (see Figure 7.19).

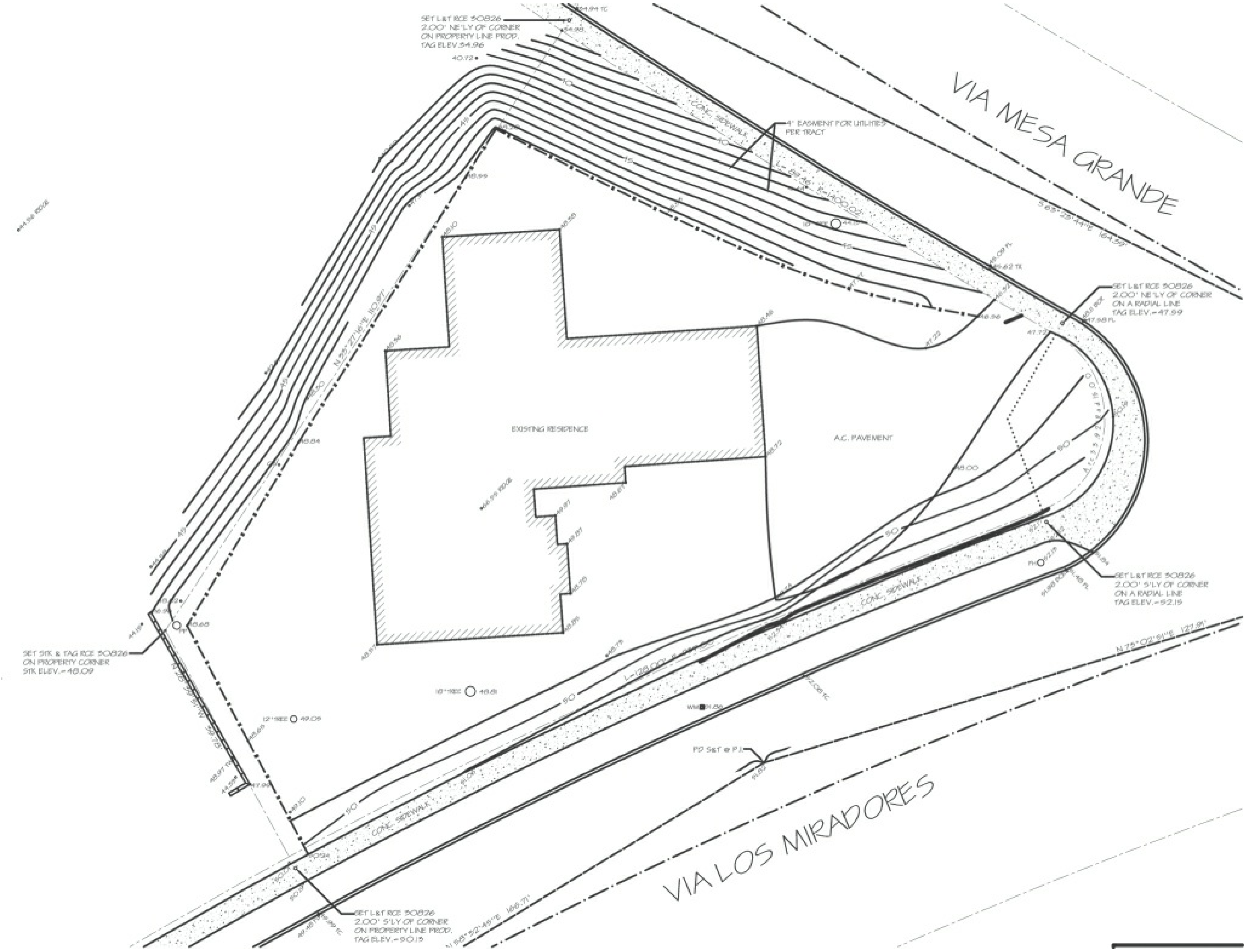


Figure 7.19 Site plan: Stage I.

Stage II. Easements that are allocated for utility purposes, such as sewers, are depicted on the drawing with a broken line. This stage of the drawing also shows the adjacent streets, street curbs, sidewalks, and pathways (see Figure 7.20). After the final preliminary building designs and their relationship to the influencing factors of the building site are determined, the building is placed on the site plan.

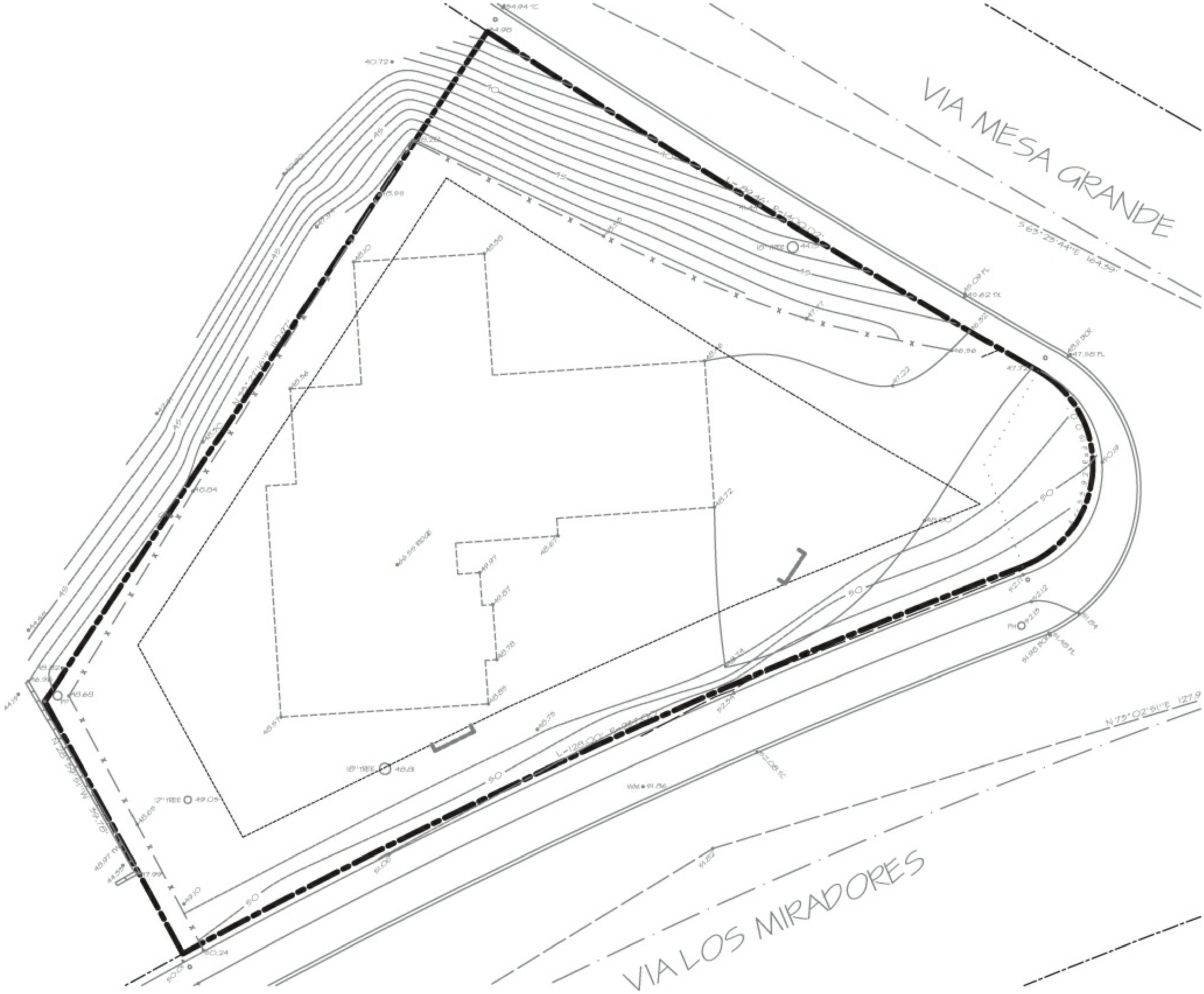


Figure 7.20 Site plan: Stage II.

Stage III. The placement of the building is derived from the final preliminary designs relative to the orientation of the sun, prevailing winds, governing setback requirements, and any existing easements. A solid line depicts the perimeter lines of the building, and a broken line indicates walls beneath. This is done to ensure that the setback dimension lines are to the perimeter wall lines. See Figure 7.21.

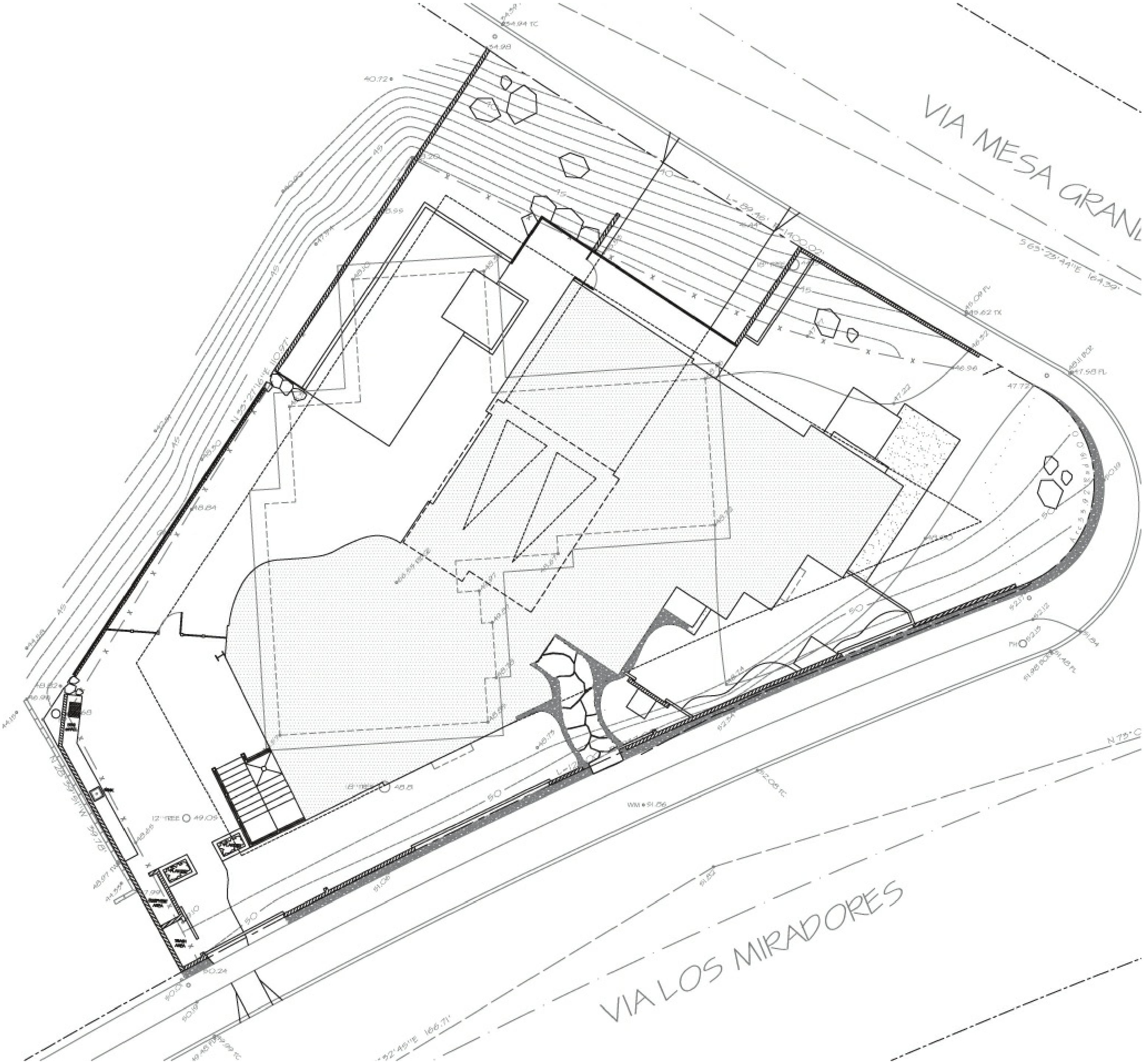
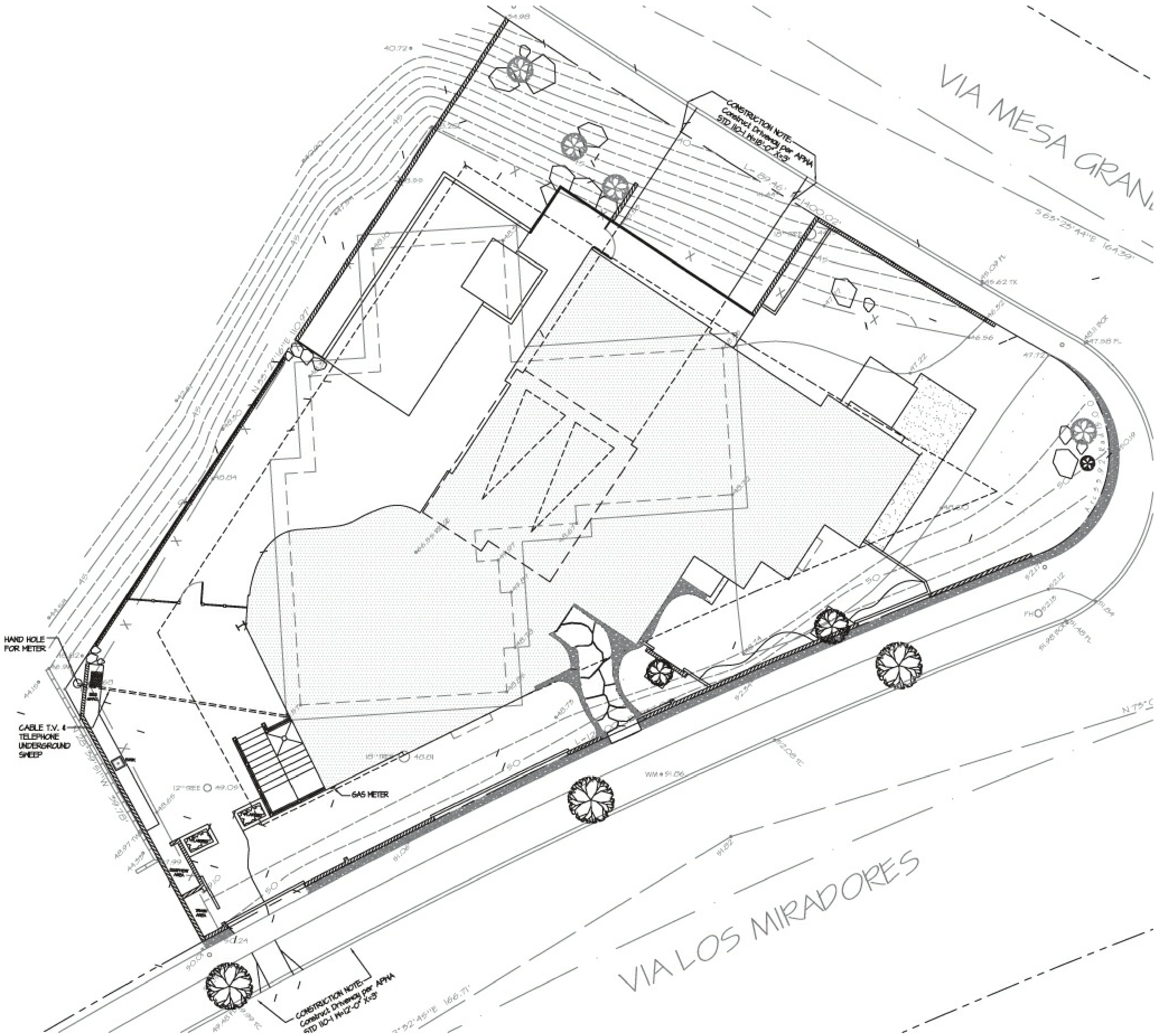


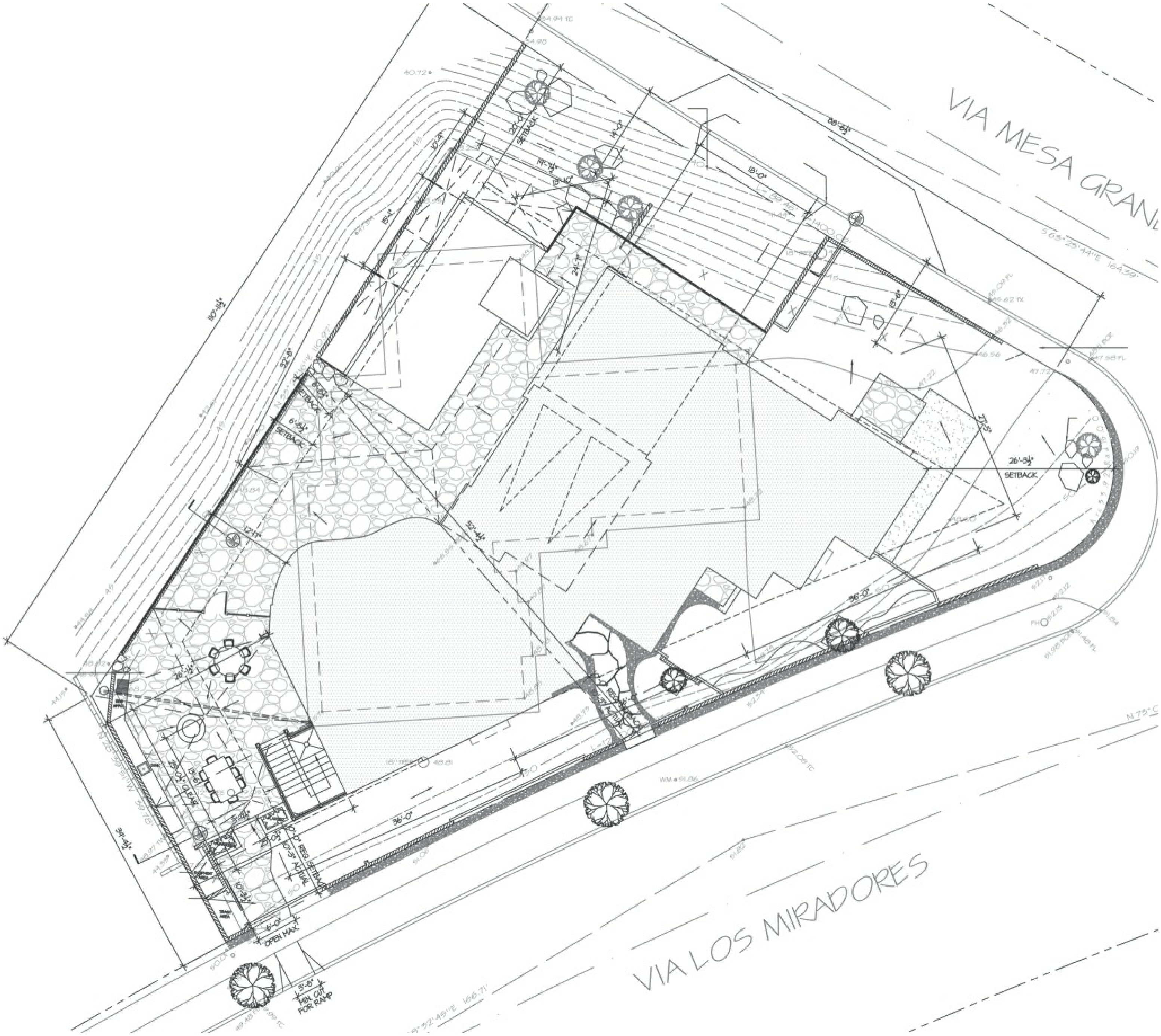
Figure 7.21 Site plan: Stage III.

Stage IV. Items such as the driveway, patio slab, garage, and any other significant features are included on the site plan. See Figure 7.22.



[Figure 7.22](#) Site plan: Stage IV.

Stage V. Provide the finish contour lines, which are drawn with a solid line and connected to their correlating grade elevations. The numerical elevation grades have been added, representing 1…foot intervals. Dimension lines and their values are now shown from the property lines to the perimeter wall lines of the building for layout purposes. Also shown in this stage are the property line dimensions and their bearings. See Figure 7.23.



[**Figure 7.23**]() Site plan: Stage V.

When dimensioning a site plan, locating the building is the primary goal. There are no other plans in an architectural set of drawings that will position the building on the site. That is not to say other dimensions are not important: they are, but the locating of patios and other site features is secondary.

Stage VI. The final stage includes all the required noting. The finish noting on the site plan includes material finish, the walkway material, and any required specifications. In addition, the title and notes are included on the plot sheet. See Figure 7.24.

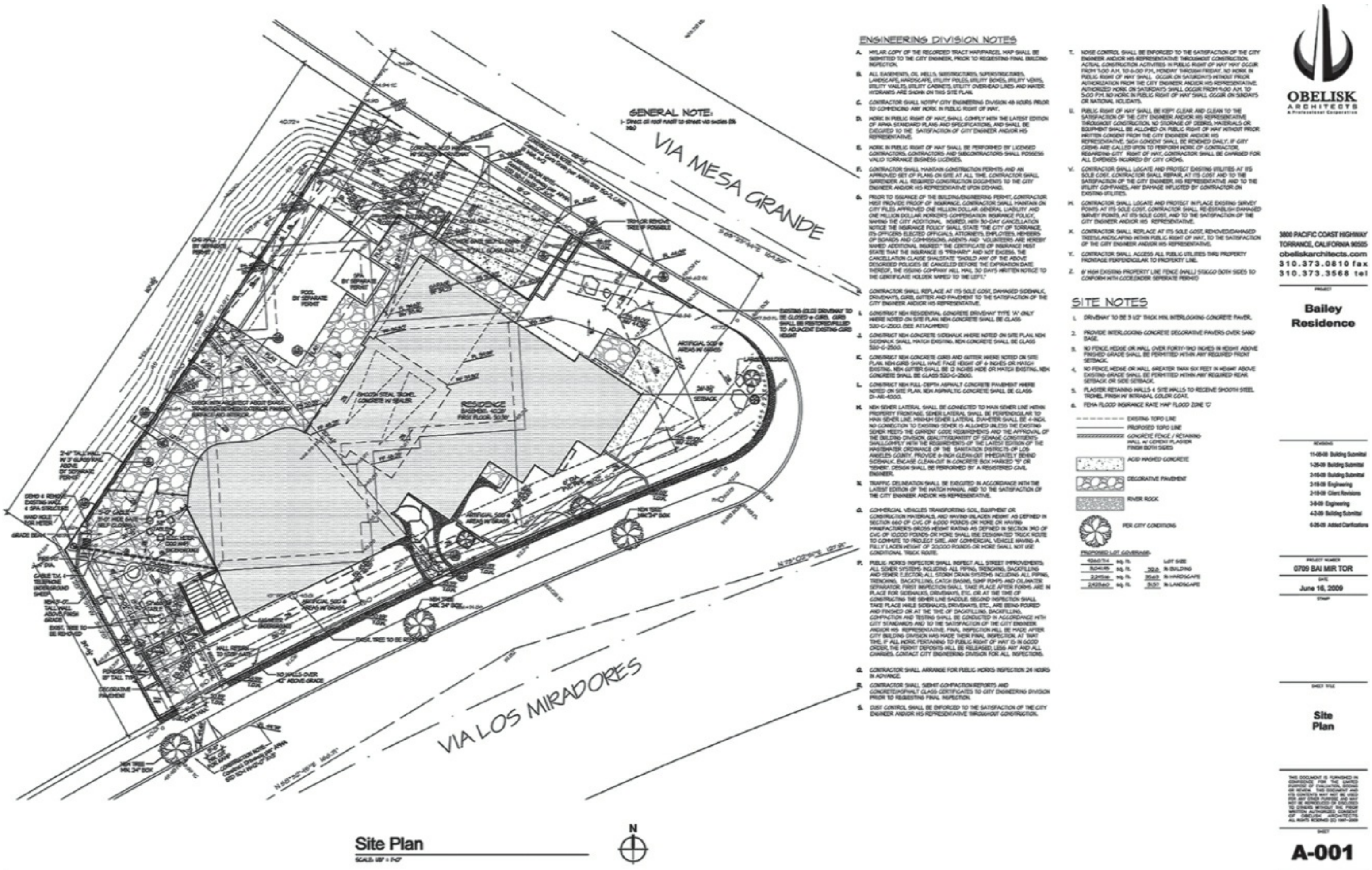


Figure 7.24 Site plan: Stage VI.

(Courtesy of the Bailey residence.)

For clarity, all the various floor elevations should be labeled on the site plan. In addition, a symbol legend should be provided, to define those symbols used on the site plan. Finally, the title of the drawing is shown, along with the north orientation arrow, the street name, and the scale for the site and roof plan drawings.

GRADING PLAN

Grading

The grading plan shows how the topography of the site will be changed to accommodate the building design. This plan shows the existing grades and proposed grades, which are termed **finished grades**. It also indicates the finished grade elevations and the elevations of building floors, walks, and site walls. Existing grade lines are shown with a broken line, and proposed finished grades with a solid line. Finished grading lines represent the end result or desired layout once the site is graded. See Figure 7.25.

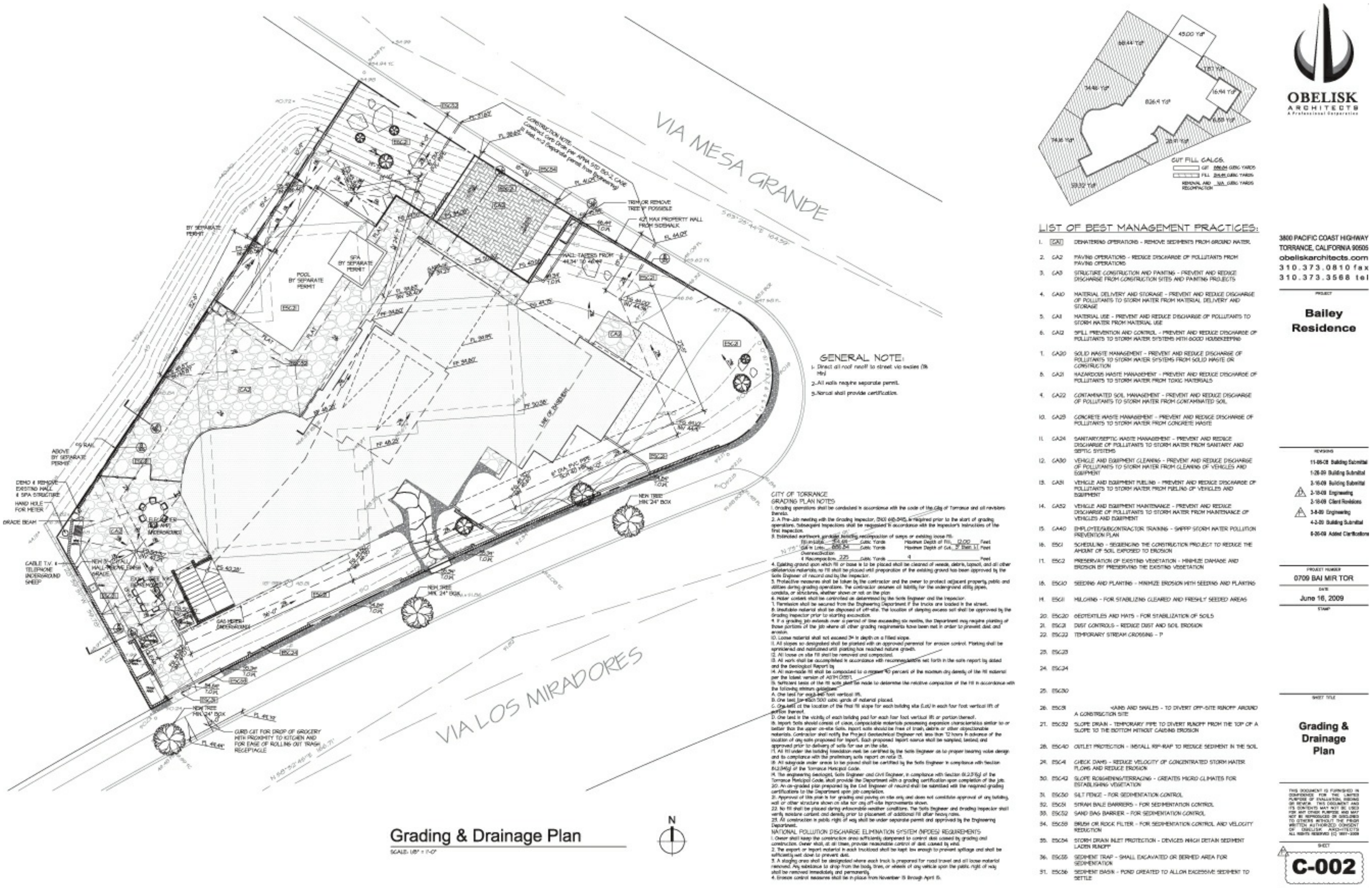


Figure 7.25 Grading plan.

(Courtesy of the Bailey residence.)

The grading plan drawing illustrates and defines the various alterations of the land contours that are needed to develop the site for a specific structure.

Floor Elevations

Once the orientation and location of the building have been established, the process of preparing a grading plan may begin. The first step is to designate tentative floor…level elevations, which will be determined by the structure's location in relation to the existing grades. It should be noted that in the process of designing a grading plan, tentative floor elevations may have to be adjusted to satisfy the location of the finished contours and their elevations. With the establishment of the floor…level elevations, it will then be necessary to reshape the existing grade lines to satisfy floor clearances and site drainage control. See Figure 7.26.

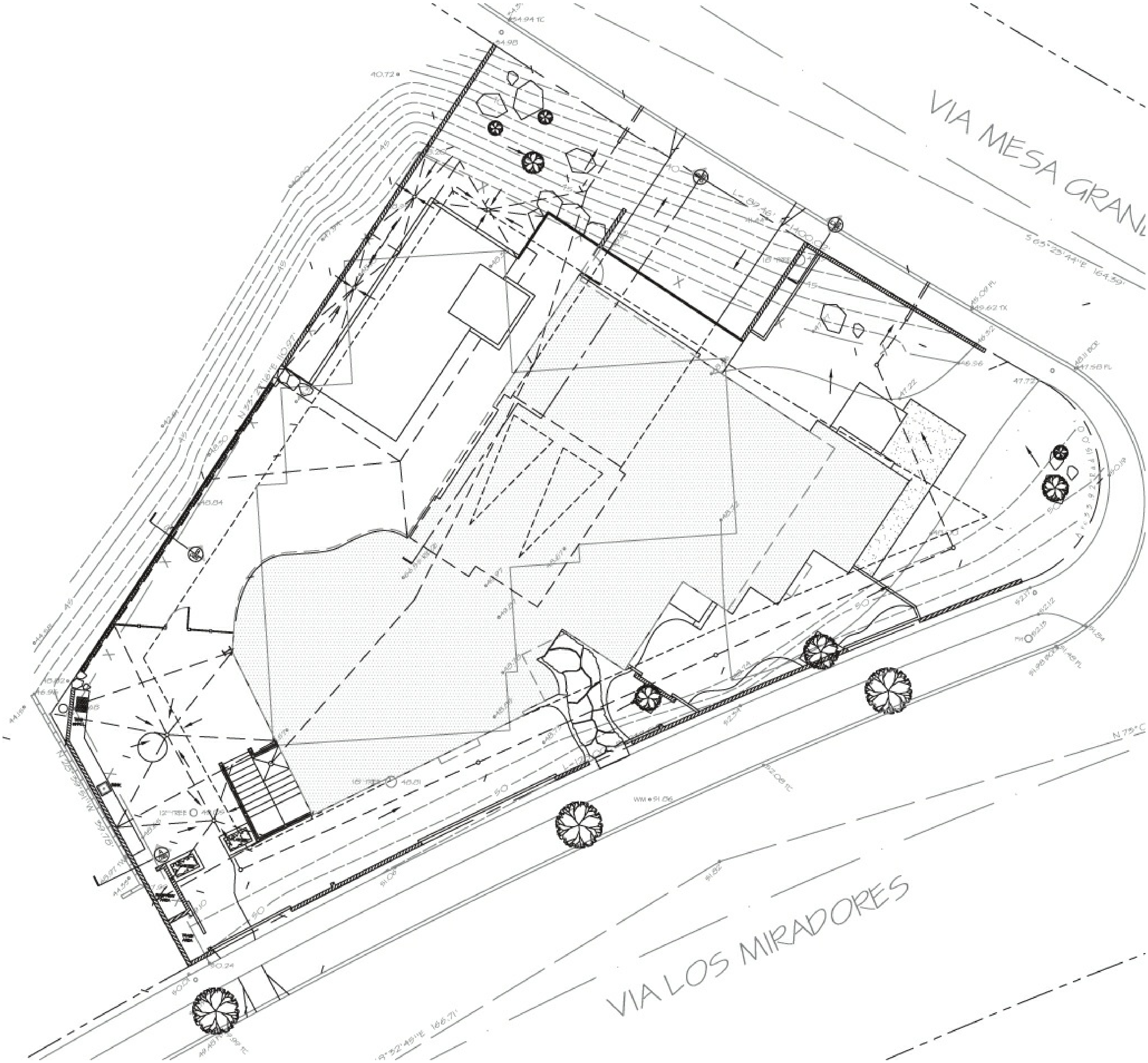


Figure 7.26 Initial grading.

(Courtesy of the Bailey residence.)

For the purpose of providing proper drainage around the building, the designer should encourage surface drainage to flow to each side of the building and follow the natural slope of the site. Finished contour elevations will be shaped to provide a gentle slope around the front and sides of the building. A minimum 2% slope is recommended for proper drainage of soil areas.

Orienting a structure on the site with a minimum amount of finished grading is the most environmentally sensitive response to a site. Once the primary location and floor elevation have been established for the garage, the formation and planning for the

residence may now proceed, with the intention of ensuring compatibility with the existing grade elevations and the contour configurations of the existing grades. The architect may decide to develop a building configuration that will accommodate minimal finished grading conditions and provide a development that is more compatible with the natural terrain.

In designing a more severe slope, as in cases where a building pad must be enlarged, a maximum slope ratio is laid out. **Slope ratios** are laid out with horizontal scaled increments for the tentative slope ratio. For instance, in some counties a ratio of 2:1 is the minimum slope allowed for each site contour. This would allow a site to increase 1 foot in height for every 2 feet traveled in the horizontal direction. A slope ratio of 3:1 is a more gradual slope, and in many areas an ideal target for slope stability. Slope ratio is anticipated for the grade cut for the placement of the building. Increments will start from the established grades adjacent to the building. Once the various increments have been plotted, these points can be connected. In most cases, all finish grade elevations start at an existing or natural grade elevation and terminate at the respective existing grade elevation. See Figure 7.27.

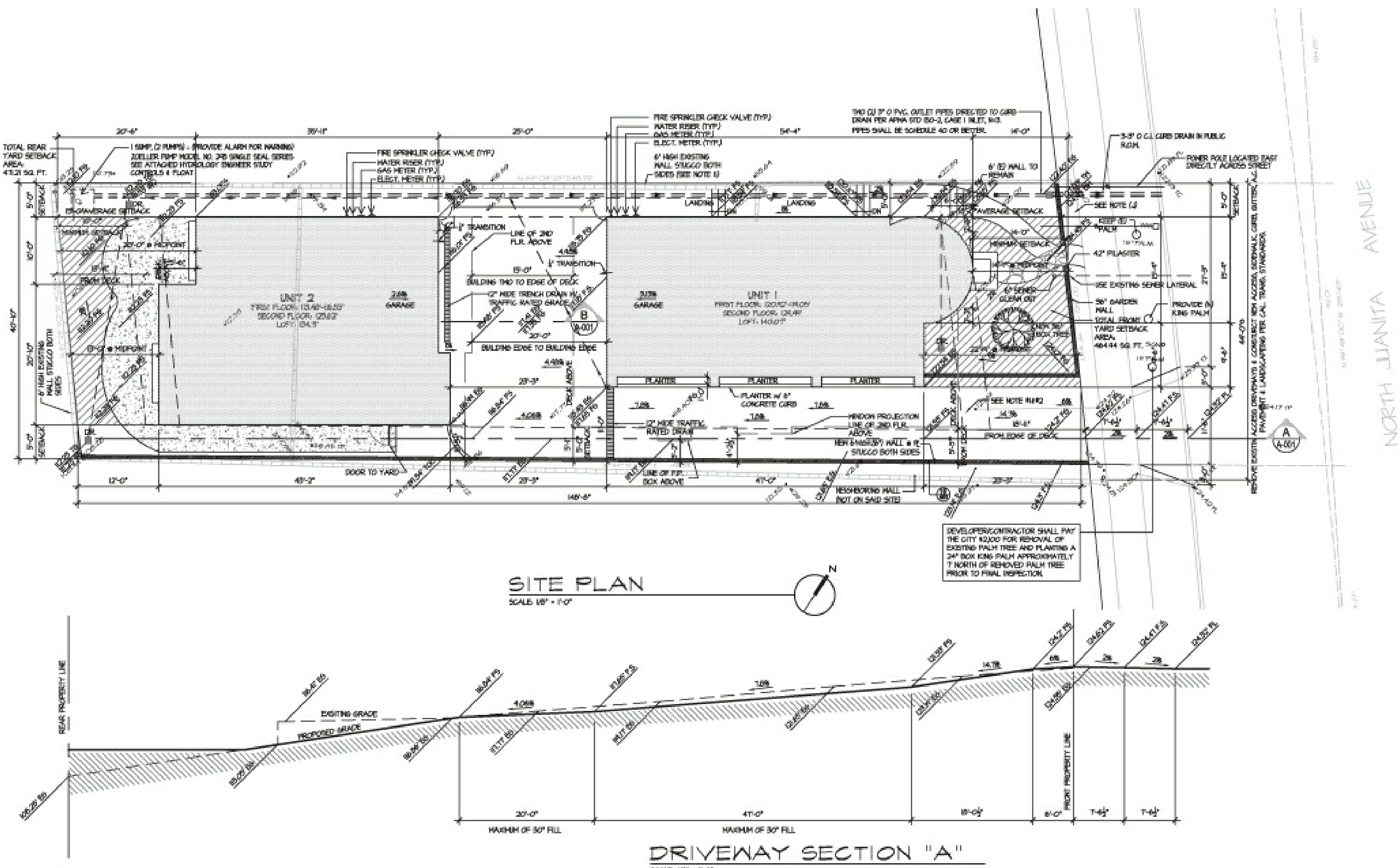


Figure 7.27 Finished slope design.

Cut and Fill Procedures

Contour changes will require either the removal of soil—a **cut** into the existing contours

—or the opposite, the addition of soil to the site; the latter is called **fill**. In reshaping contours with cut and fill procedures, one can provide a relatively level area for construction. Depending on the soil's condition and soil preparation, the maximum allowable ratio for cut and fill slopes may vary from 1½:1, 2:1, or 3:1. A ratio of 3:1 means that for each 3‐foot distance on the horizontal, there is a minimum 1‐foot change in vertical elevation. A slope of 3:1 establishes a stable slope that is less likely to slide. In some municipalities, a maximum slope of 3:1 is required for cut and fill. To clarify grading conditions, grading sections should be taken through these areas. See Figure 7.28.

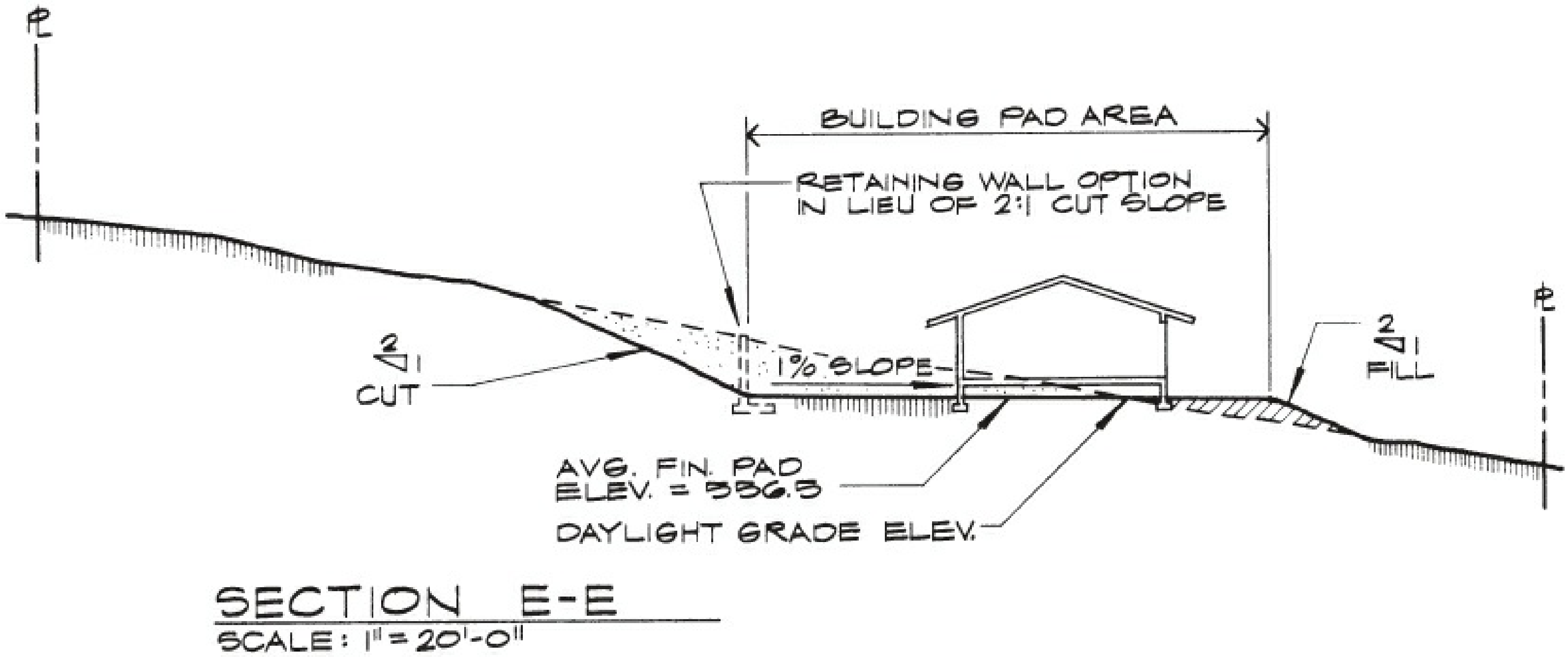


Figure 7.28 Cross‐section with finish grades.

Another approach is to develop a level area on a site for the construction of a residence. The level area, called a **building pad**, will have a minimal slope for drainage of approximately 2%. The creation of a building pad will provide the architect with more flexibility in the design, because he or she will not be constrained by grade elevations, floor transitions, building shapes, or other considerations.

One approach in developing a building pad is to try to create a balance cut and fill. In this approach, the earth that is cut from the site slope is dispersed and used as the fill material to increase the building pad site. The fill material must then be **compacted** to an acceptable soil‐bearing capacity if a structure is to be founded in the fill area. To develop the size, shape, and grading for the building pad, it is recommended that an assumed pad elevation be established. This pad elevation may be determined by what is referred to as a **daylight grade elevation**, defined as that point or elevation where the cut and fill portions of the site grading intersect at a given grade elevation.

SITE AND GRADING PLAN

In this section, we discuss and illustrate another example of grading design and the various criteria that dictate design solutions, this time for a two‐story residence. The

topography map for this project is shown in Figure 7.29. Note that the natural or existing grades are indicated with a broken line and a designated number indicating the grade elevation of each contour line.

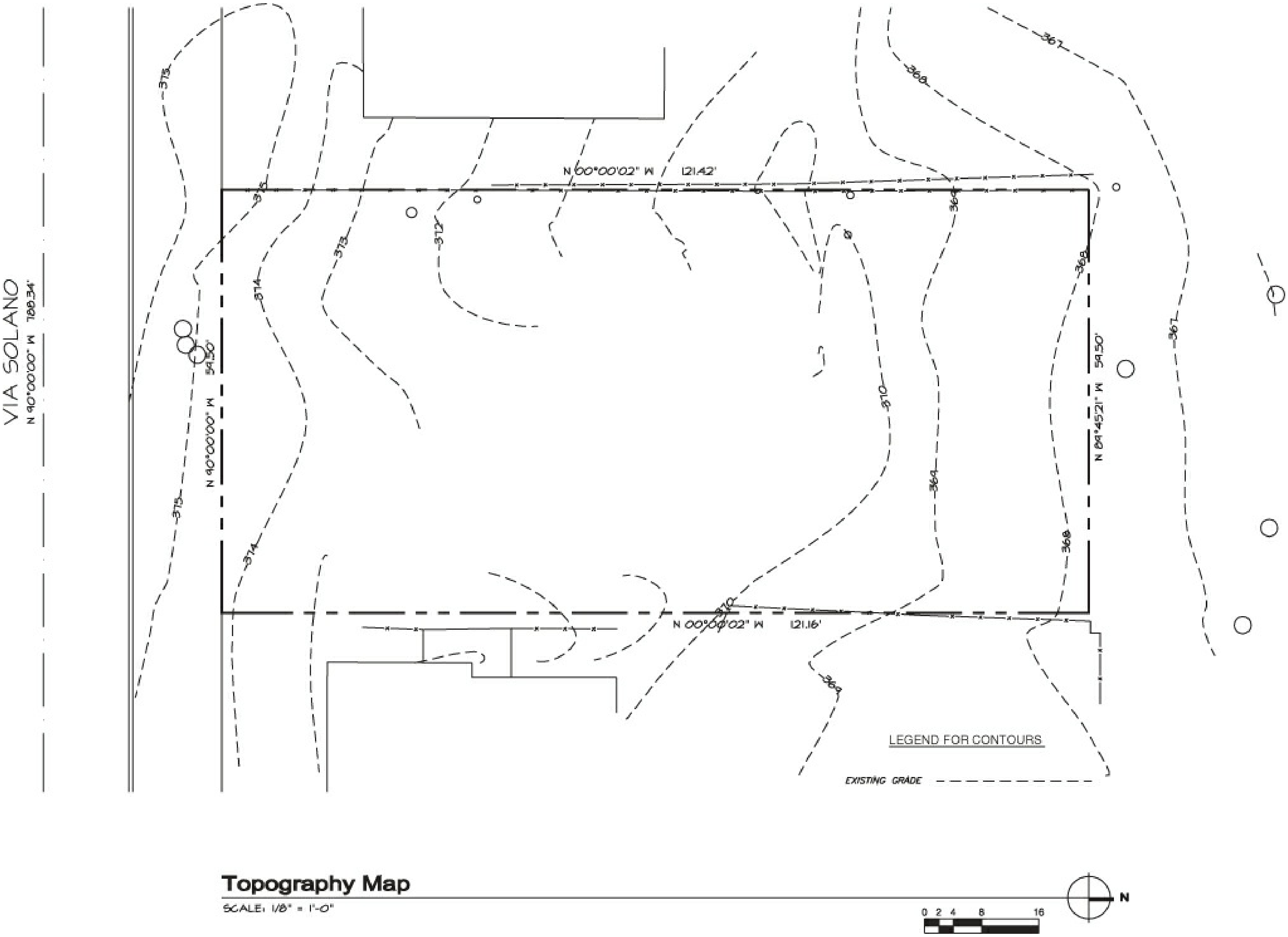


Figure 7.29 Topography map.

For this project, the initial concern was the driveway access and slope relative to the garage floor elevation. The desired maximum slope of the driveway does not exceed 1 foot in 10 feet (1:10). This translates into a slope of 10%. Starting at the southerly property line, which is the front property line, the existing contour grade elevation is 375.00′. From this existing grade elevation of 375.00′, it is desirable to maintain a maximum driveway slope of 10% within the 15′…0″ building setback area. This design solution then establishes the garage floor elevation at 372.50′. This condition is illustrated in Figure 7.30. Note that a trench drain is located in front of the garage to divert any water accumulation from the sloping driveway. This trench drain will have a grate cover and drain lines to dissipate the water.

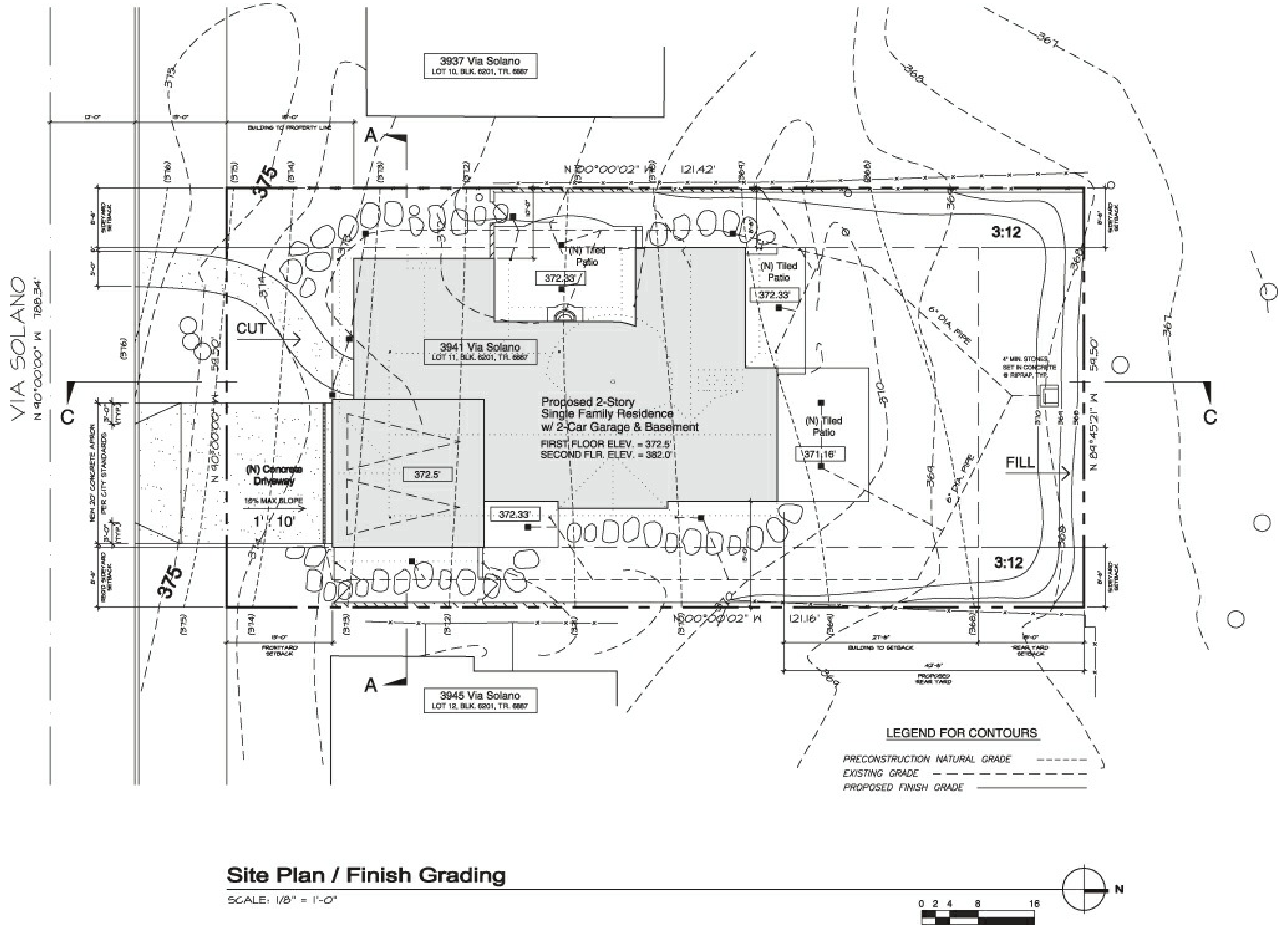


Figure 7.30 Site plan/finish grading.

Another concern in dealing with sloping driveways is the transition from the street and the driveway apron elevation to the sloping portion of the driveway. This concern is illustrated graphically in the driveway transition section shown in Figure 7.31. Note the hypothetical driveway transition, depicted with a broken line, which shows steep slope transitions that may cause under…car damage and/or bumper scraping.

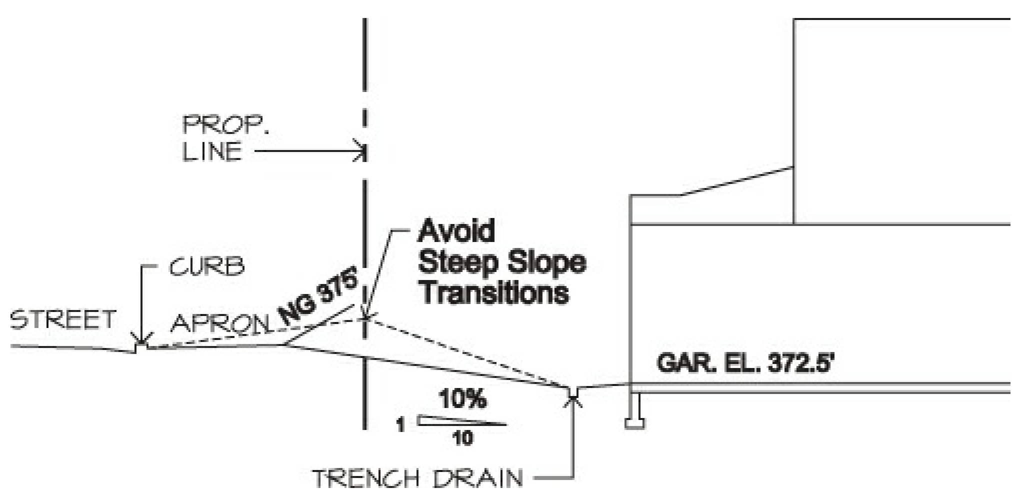


Figure 7.31 Driveway transition section.

The first step is to develop the grading for a driveway that will provide acceptable slopes for access to the garage, which will in turn determine the garage location and floor elevation. Starting at the street grade elevation, the initial grade transition from the street to the driveway should not be so steep as to scrape the bumper of an automobile. The initial maximal slope ratio is approximately 1 foot vertically to 10 feet horizontally (1:10), or a 10% slope. A slope of 20% or a 1:5 ratio would be the maximum allowable in most jurisdictions.

Although a 20% driveway can be utilized with appropriate transitions of 10% at the beginning and ending of the 20% area, approximately 8 to 10 feet of 10% grade, then 20%, and then another 8 to 10 feet of 10% will allow a smoother transition for vehicles. A goal for a contoured lot is to work with the existing topography, but an ideal smooth slope of 12.5% or less is comfortable. In addition to the vertical slope, the length of a driveway maximum cross…slope, measured at the width, would be 10% (ideally, less than 5%). In each region of the country, the local municipality will establish the maximum for this condition.

It is not recommended that one exceed a 20% driveway slope. A maximum 4% slope is recommended for the side…to…side slope or **cross…slope** of the driveway. As mentioned previously, the garage floor elevation has been established at 372.50′. From the garage floor elevation, a 6″ floor transition will determine the first…floor elevation to be 373.00′. The garage floor and first…floor elevations will now become the basis for the finished grading design. See Figure 7.32. The existing grade lines of the site slope gently down from the southerly property line to the northerly property line. This condition, based on the established garage and first…floor elevations, will require an earth cut at the front or southerly area of the site, with the soil removed being relocated to the rear or northerly portion of the site, which becomes a fill area. The solid lines illustrate the finish grade contours, as depicted in Figure 7.32. Note that the finish grade line elevations connect to the existing grade line elevations. Figure 7.32 graphically illustrates a cross…section of the building site cut in a south…to…north direction. The broken line depicts the approximate existing grade, and the solid line and shaded areas show the finished grade line and fill areas. Additional cross…sections in relationship to abutting properties are illustrated in Figure 7.33.

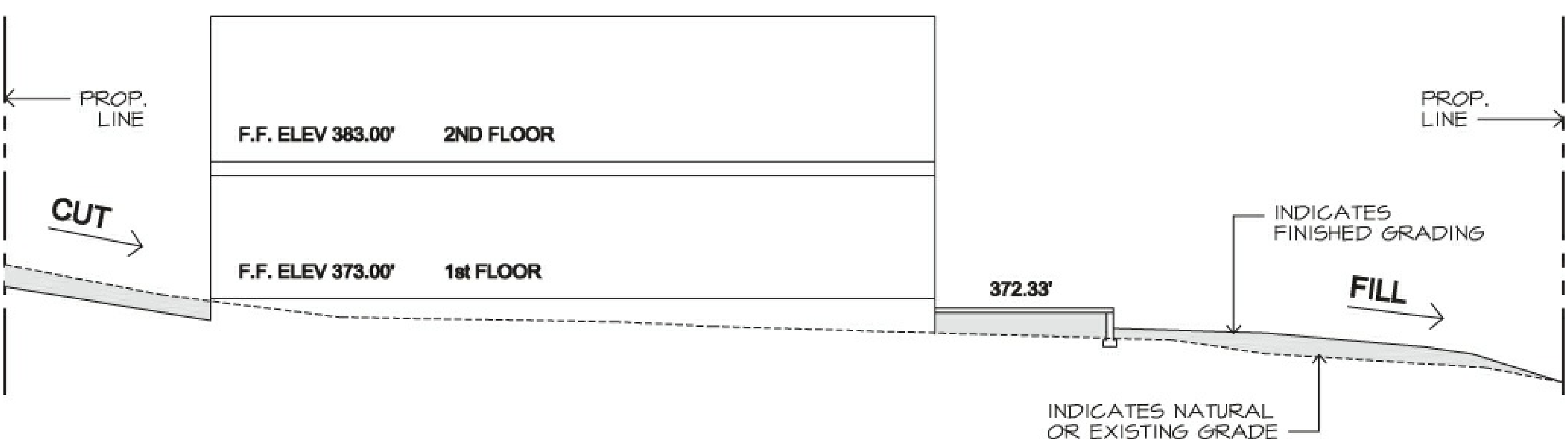


Figure 7.32 Site grading cross…section.

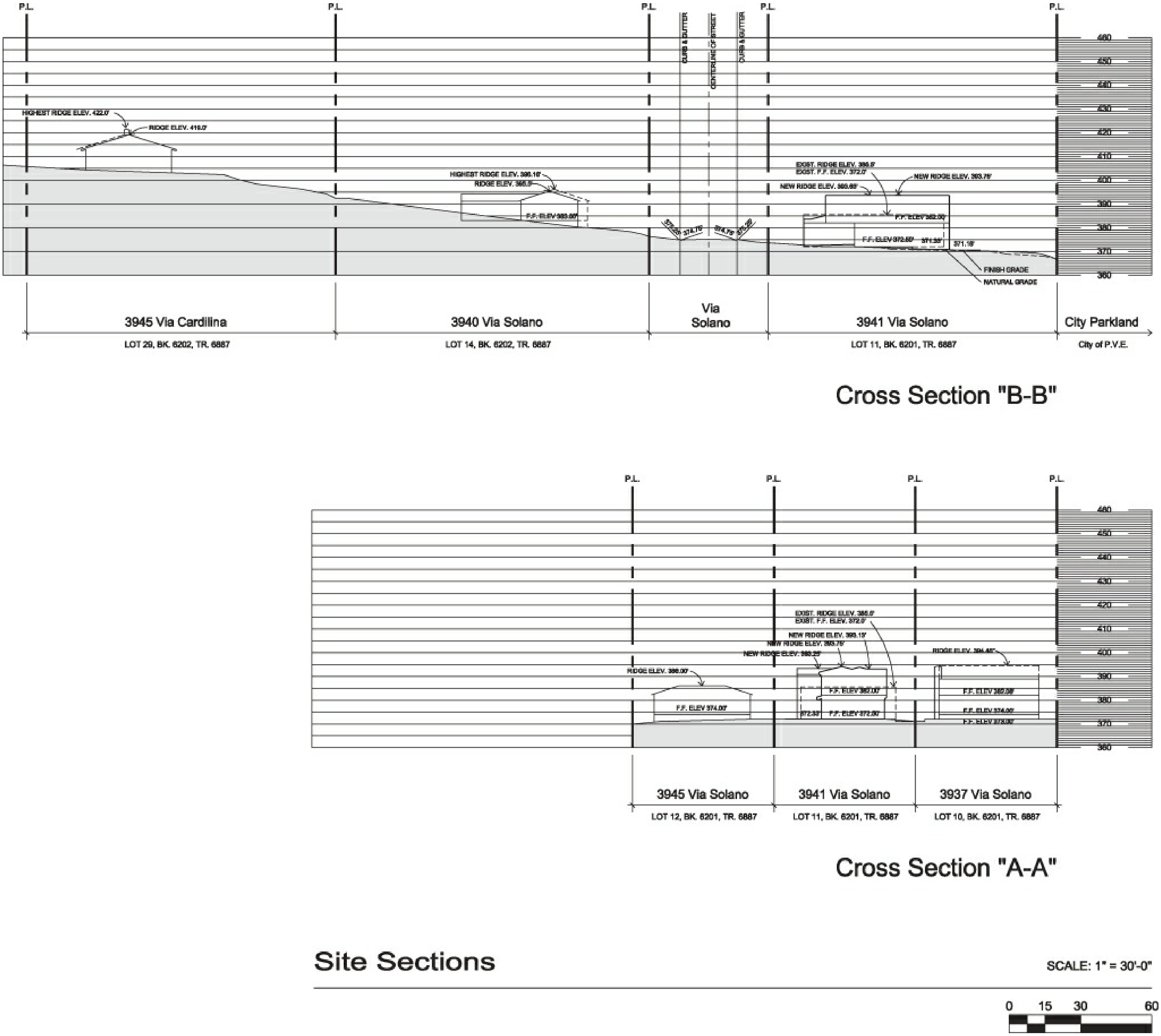


Figure 7.33 Site sections.

The maximum slope or gradient for cut and fill slope conditions may be determined by the type of soil found on the site and local agency requirements. Various soil types react differently to potential soil erosion. For most cases, the maximum slope or gradient may range from 1, to 1½:1, to 2:1. These ratios translate into 66% and 50% slope conditions, respectively. See Figure 7.34.

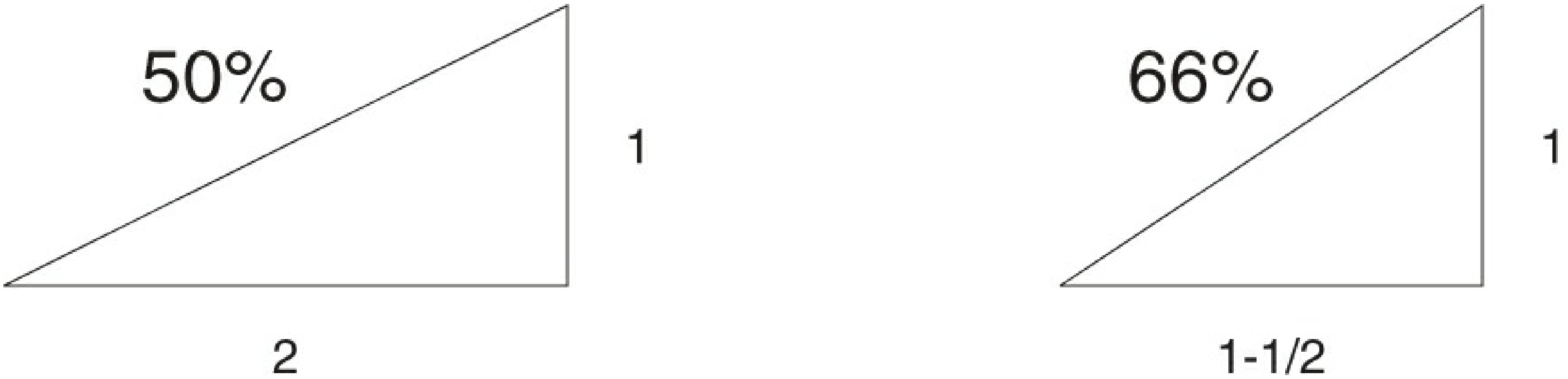


Figure 7.34 Slope ratios.

Driveway and Curb

Often, one side of your site will be bounded with a sidewalk, parkway, and a small curb. In most cities, this portion adjacent to a street is maintained by the Department of Public Works or some other such municipal agency. Permits are required to break the curb for a driveway; permits can be obtained from the appropriate agency or agency subdivision (perhaps the city's Road Department Bureau or engineering department). Based on the size of the curb, the agency will configure an angle at which you can cut the curb to form the driveway. See Figure 7.35.

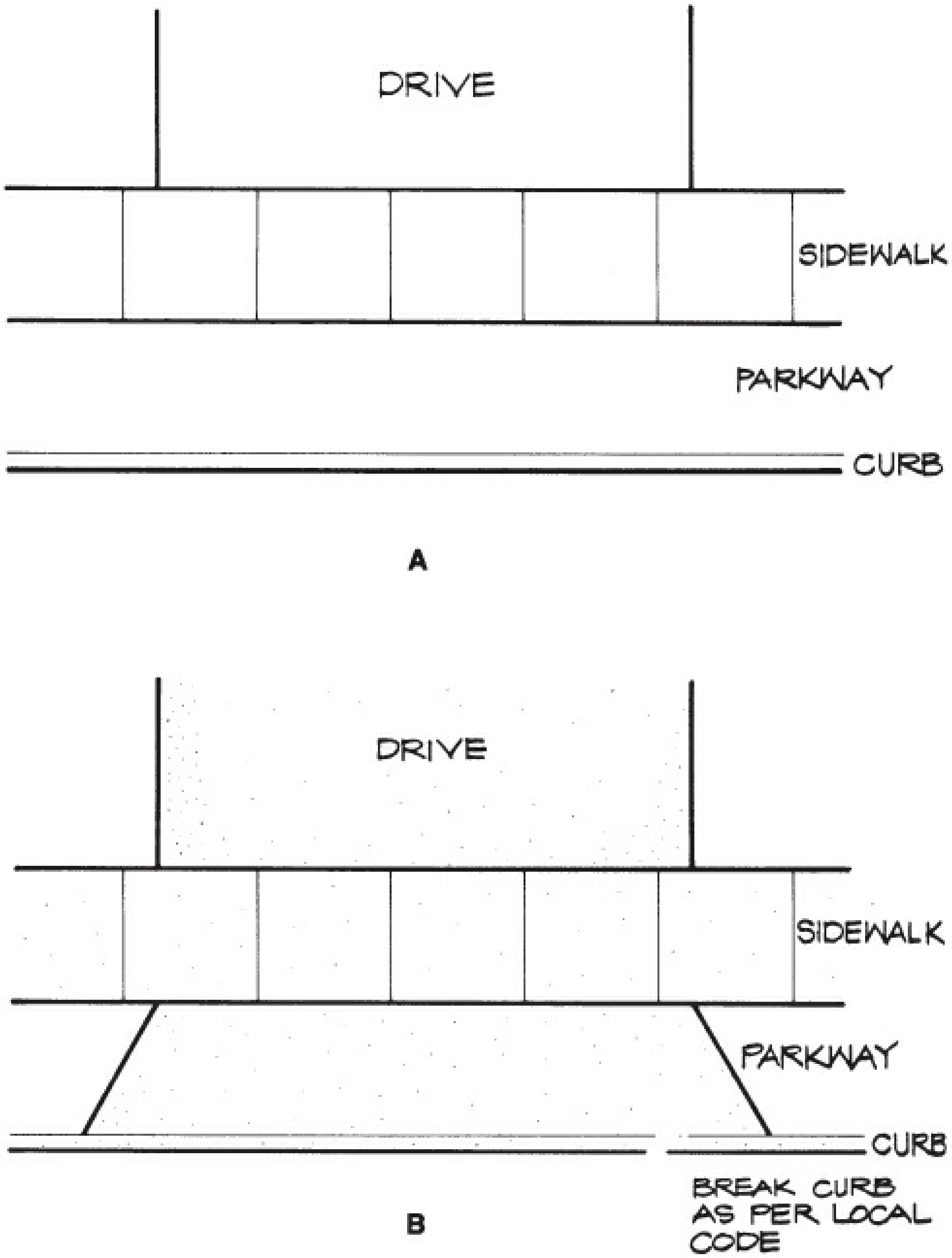
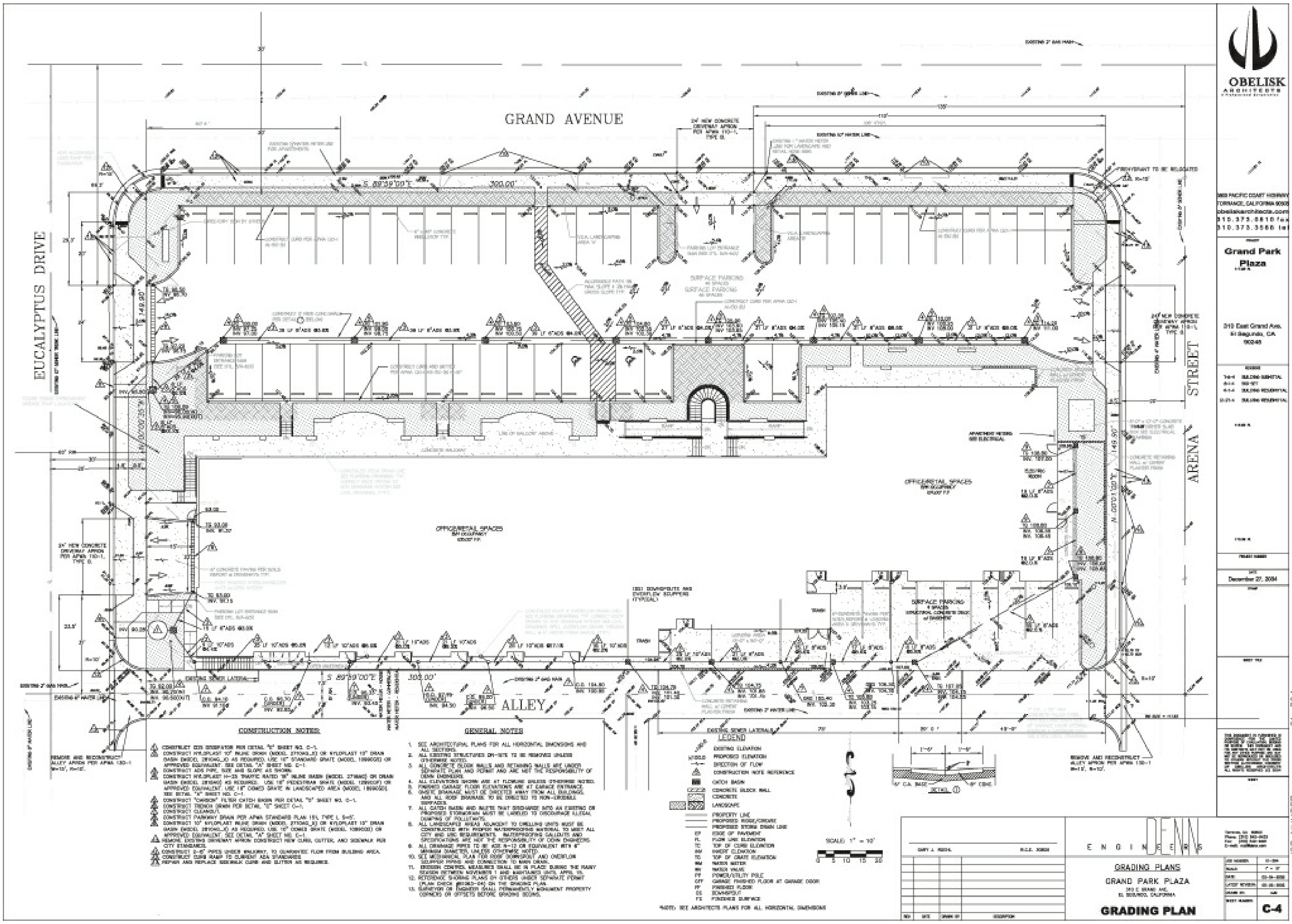


Figure 7.35 How to break a curb for a driveway.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings*, 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Commercial Site Grading

For sloping sites that are going to be developed for commercial and office use, the grading design will have to address automobile and disabled pedestrian access to the building. The transition from the street to the parking area should provide easy access relative to the driveway slope and the slope of the parking area. Grade transitions that require stairs and landings will also require ramps for people with disabilities, which are regulated by the Americans with Disabilities Act (ADA) requirements. See Figure 7.36.



[Figure 7.36](#) Existing grade.

(Courtesy of Denn Engineers and Mr. Kizirian.)

DRAINAGE PLAN

A **drainage plan** establishes the path by which water travels on a site, often in a controlled method via a nonerosive device. Such devices include pipe, area drains, sub…drains, drains, catch basins, drainage swales, diverters/interceptors, and bio…filters. Other controlled methods include shaping of grade, berms, driveways, splash walls, riprap, and velocity reducers. **Area drains** are inlets that allow excess water collected on the surface of an area to be rerouted with pipes below grade. A drain is typically located in a hard paved area where a **sub_drain**, sometimes called a **french drain**, collects excess water below grade (for example, behind a retaining wall). These too are connected to a pipe and outlet. On large sloping sites, it is difficult to control water and channel the flow into area drains. In these cases, a **swale**, a “V”…shaped catching device, is used to divert the water flow. These swales will gather the excess water and carry it to a **catch basin**. **Bio_filters** are a new addition to the drainage arsenal. Bio…filters are devices designed to catch harmful chemicals or silt in surface runoff. There are many types of bio…filters; consult

regional codes for proper choice and fabrication. Often, shaping the grade with berms or a 2% slope can route runoff in the right direction. Even a driveway can have a low point to guide water; splash walls and raised curbs are also effective methods. When water flow is excessive, implementation of a velocity reducer or a riprap area may be required. This slows the water flow and disperses the water in a fashion that limits erosion potential. See Figure 7.37.

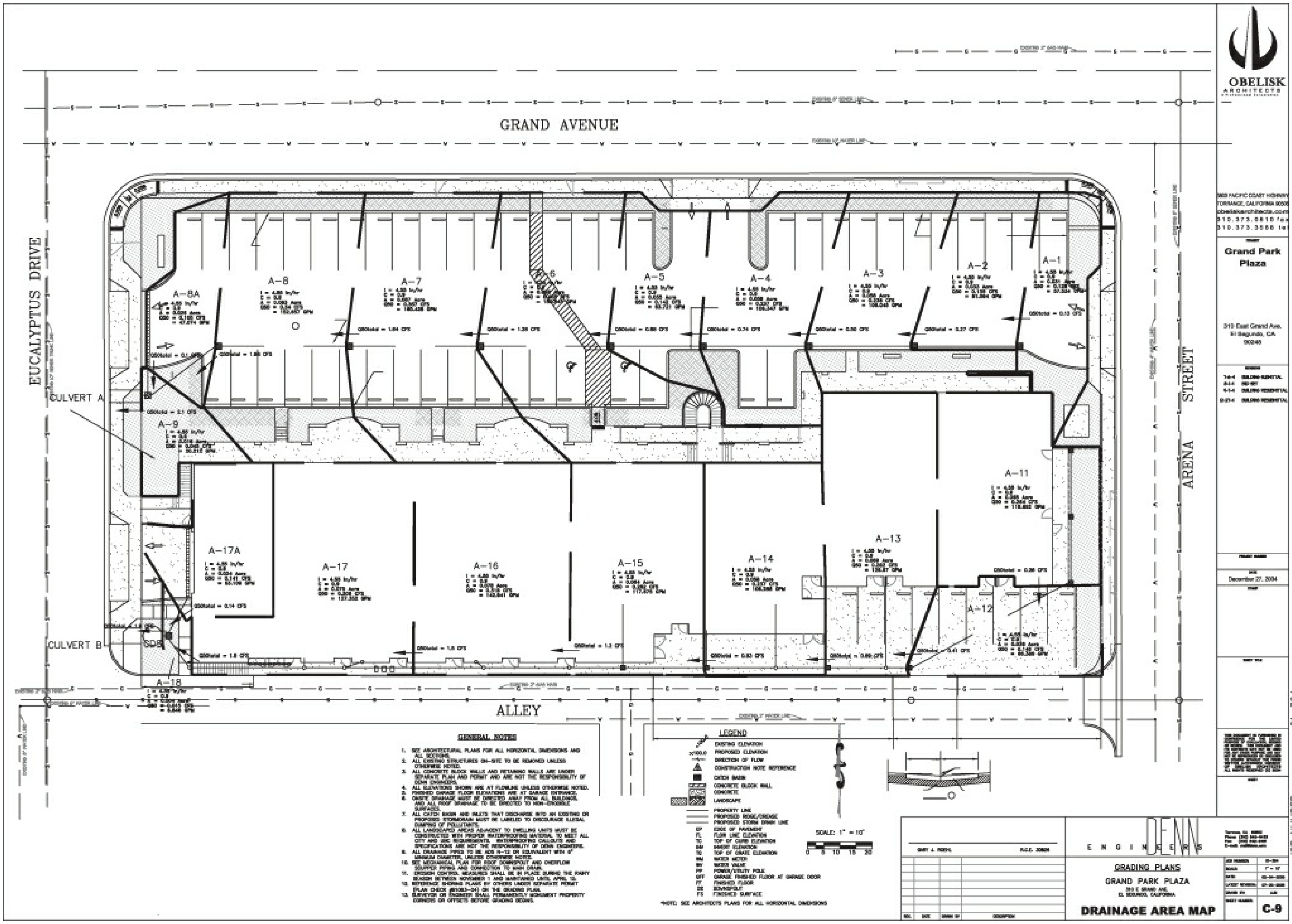


Figure 7.37 Drainage plan.

(Courtesy of Denn Engineers and Mr. Kizirian.)

The site may require that floor elevation changes be utilized to enhance the compatibility between the structure and the existing grades. The residence shape may follow the contours of the existing grade elevations and result in a unique shape or configuration. Note that some excavation will occur below the floor levels in order to provide the under… floor clearances required by building codes for wood floors.

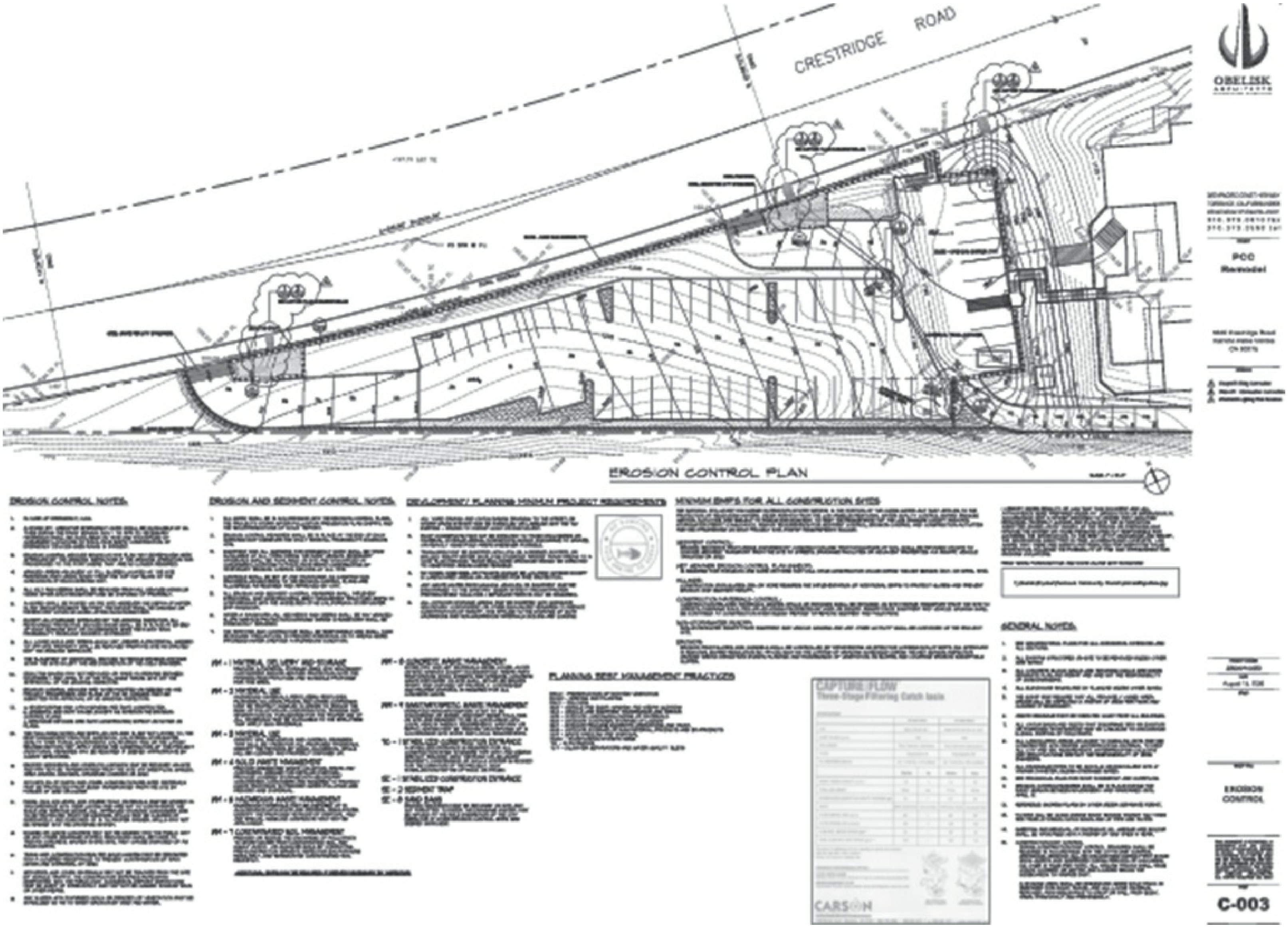
After completing an analysis of the existing grades and their contours, in conjunction with the architectural planning of the residence, a grading plan can be prepared.

EROSION AND SEDIMENT CONTROL PLANS

When construction of a building occurs in winter months, the governing agency will require a plan that demonstrates how runoff is to be controlled onsite. This plan is called an **erosion control plan**. Such a plan graphically demonstrates that water will not carry off silt, dirt, or contaminants from a site into storm drains, waterways, or neighboring sites. These can be designed utilizing:

- Sediment control
  - Silt fence
  - Hay…bale barriers
  - Sediment traps
  - Silt curtain
  - Sediment mat
  - Filter logs
- Erosion control
  - Temporary ditch checks
  - Mulch
  - Erosion control blankets
  - Compost
  - Erosion stabilization mats

These are a few methods that could be further researched when planning for erosion control. See Figure 7.38.



[Figure 7.38](#) Erosion control plan.

(Courtesy of Peninsula Community Church.)

THE UTILITY PLAN

Plotting of existing utilities is necessary to the site improvement process. See [Figure 7.2](#). Such a plan should show the location of all existing utilities, including sewer laterals, water and gas lines, and telephone, TV cable, and electrical service lines. This drawing then provides a basis for locating new utility connections. It may also influence the locations of transformers, generators, electrical rooms, and meter rooms in the structure itself.

CIRCULATION PLAN

In designing large complexes—more specifically, complexes with heavy vehicular circulation—it may become necessary to create a plan that articulates the flow of vehicular travel. These forms of plans are not complex to develop, but are informative to clients, city officials, and architects who are determining appropriate and efficient

circulation design. See Figure 7.39.

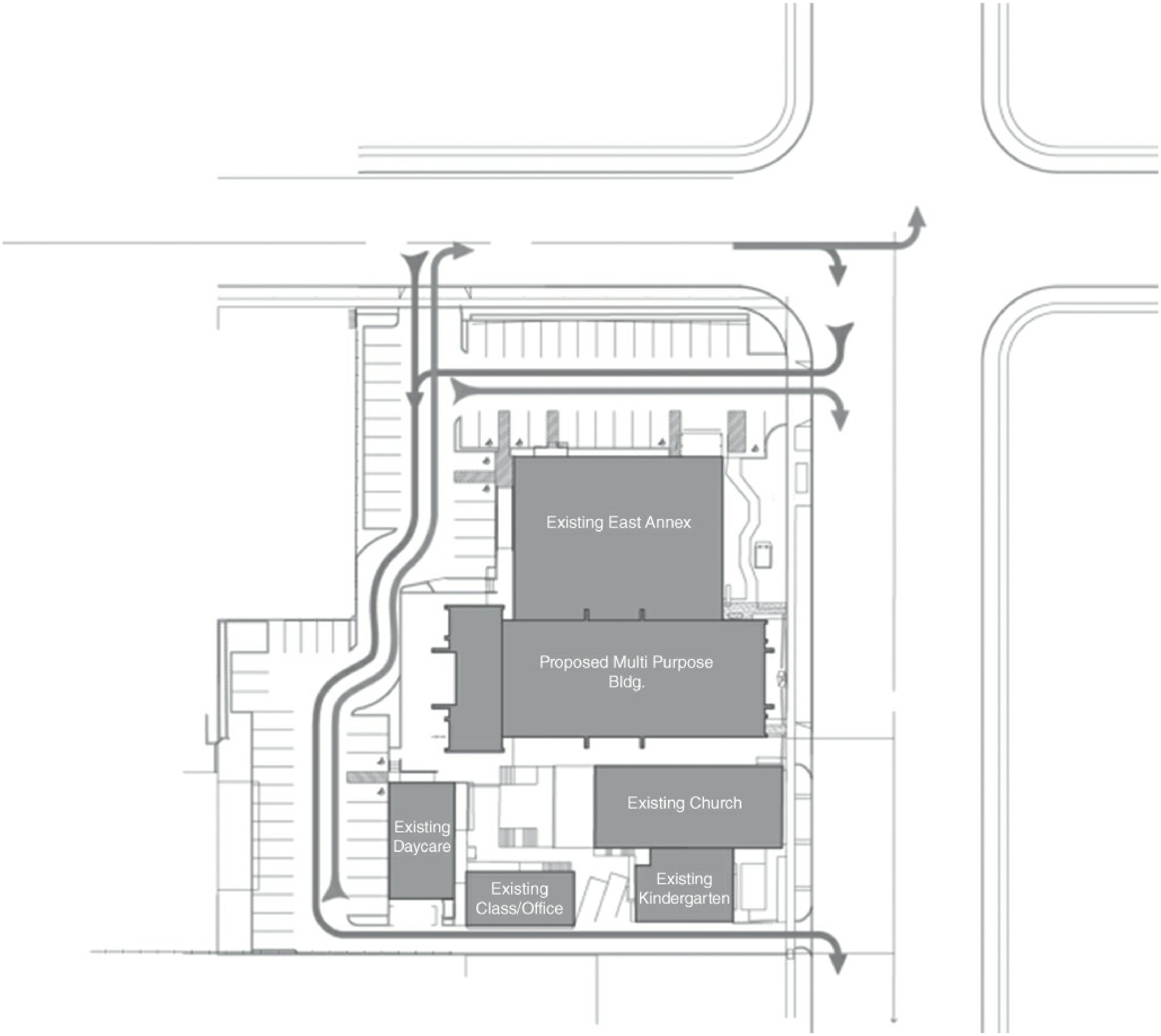


Figure 7.39 Circulation plan.

LANDSCAPE, IRRIGATION, AND DRAINAGE PLANS

Landscape Plan and Plant List

The final stage of site development for most projects is landscaping. The landscape drawing shows the location of trees, plants, ground covers, benches, fences, and walks. Accompanying this is a **plant list**, identifying plant species with a symbol or number and indicating the size and number of plants. See Figure 7.40. Often, a landscape architect will be hired as a consultant to specify the ideal plant materials and make recommendations

for the **hardscape** surrounding the project.

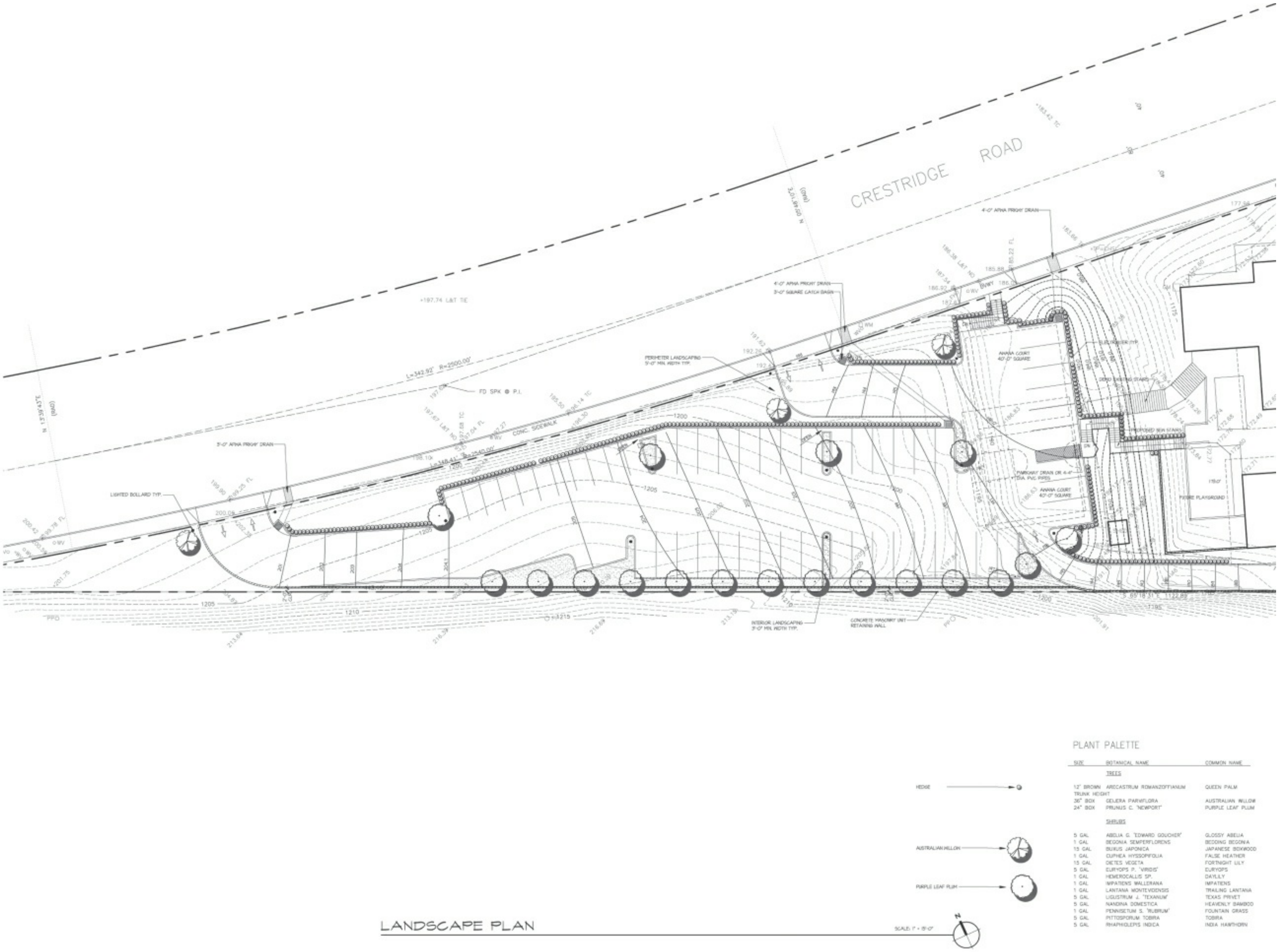
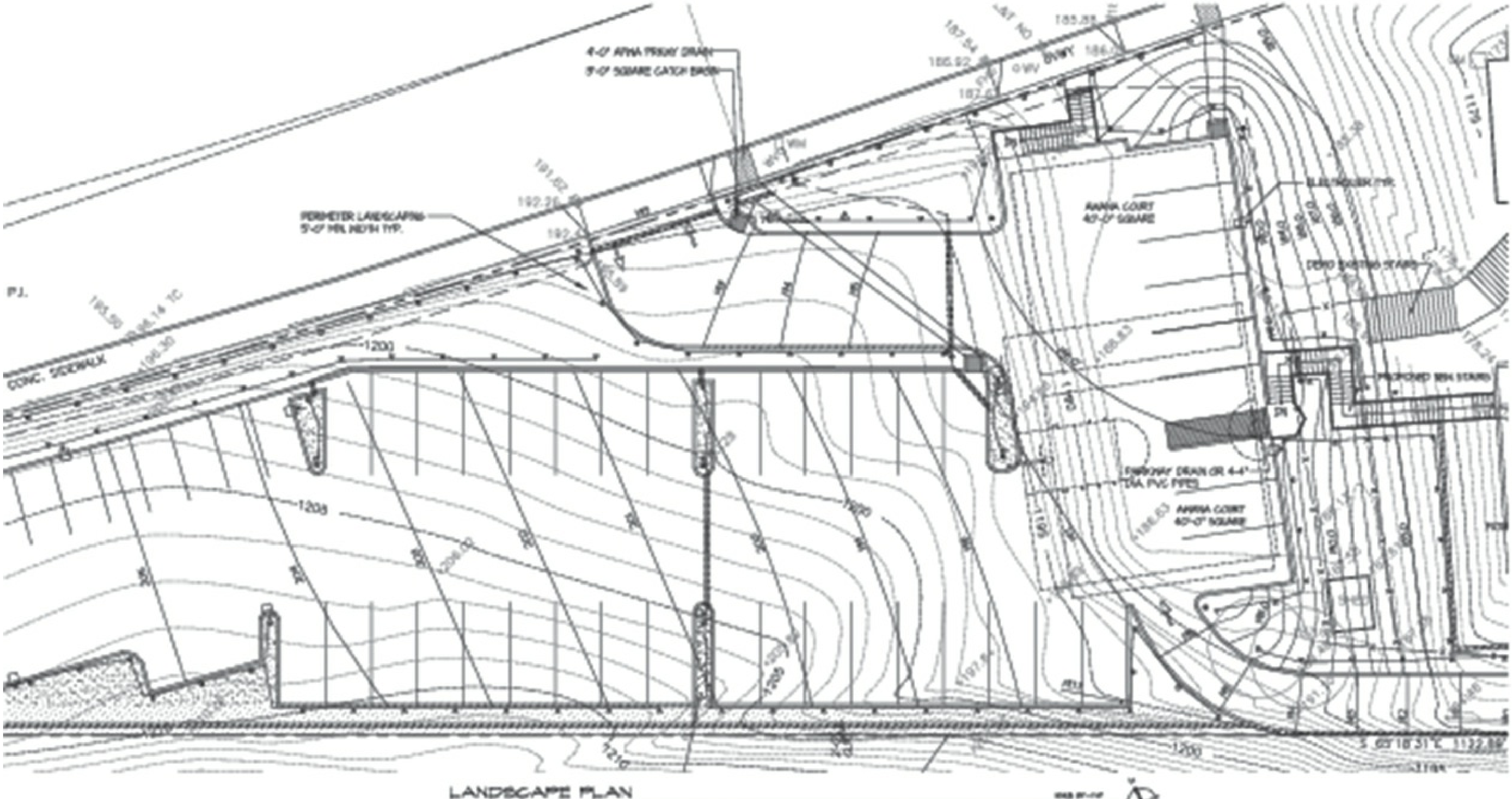


Figure 7.40 Landscape plan and material list.

(Courtesy of Peninsula Community Church.)

Irrigation Plan

An irrigation plan often accompanies the landscape plan. This drawing is typically separate from the landscape plan, but is directly influenced by the locations of plant material. This plan shows all water lines, points of connection, control valves, and types of watering fixtures required for irrigation. See Figure 7.41.



LANDSCAPE PLAN

IRRIGATION LEGEND

IRRIGATION NOTES

OBELISK

POC
Remodel

IRRIGATION
PLAN

L-004

Figure 7.41 Irrigation plan.

(Courtesy of Peninsula Community Church.)

CONCLUSION

A properly selected and designed site comes from several variables that can be determined in order to help establish the ideal condition for development of a site. Site analysis is instrumental in understanding the positive and negative features of the specific site as it relates to the clients program. Generating a site plan will locate a building vertically and laterally on a site while a grading plan will demonstrate how the earth is moved to its final configuration to coincide with the building design.

The basic requirement for all construction documents is clarity. The site improvement plan is no exception. It can incorporate any or all of the plans just discussed, depending on the complexity of the information that must be communicated and on office practice.

The primary information to be found in the site improvement plan is:

1. Site lot lines with accompanying bearings and dimensions
2. Scale of the drawing
3. North arrows
4. Building location with layout dimensions
5. Paving, walks, walls with their accompanying material call…outs, and layout dimensions

Figure 7.42 shows the primary information found on a site improvement plan. The building layout dimension lines must be noted to their respective property lines, providing two measuring points at each side of the property lines. This, in turn, provides the location of the building on the site. This is helpful when the property lines do not parallel the building. This method may apply to patios, walks, paving, and walls, which are also dimensioned on the site improvement plan.

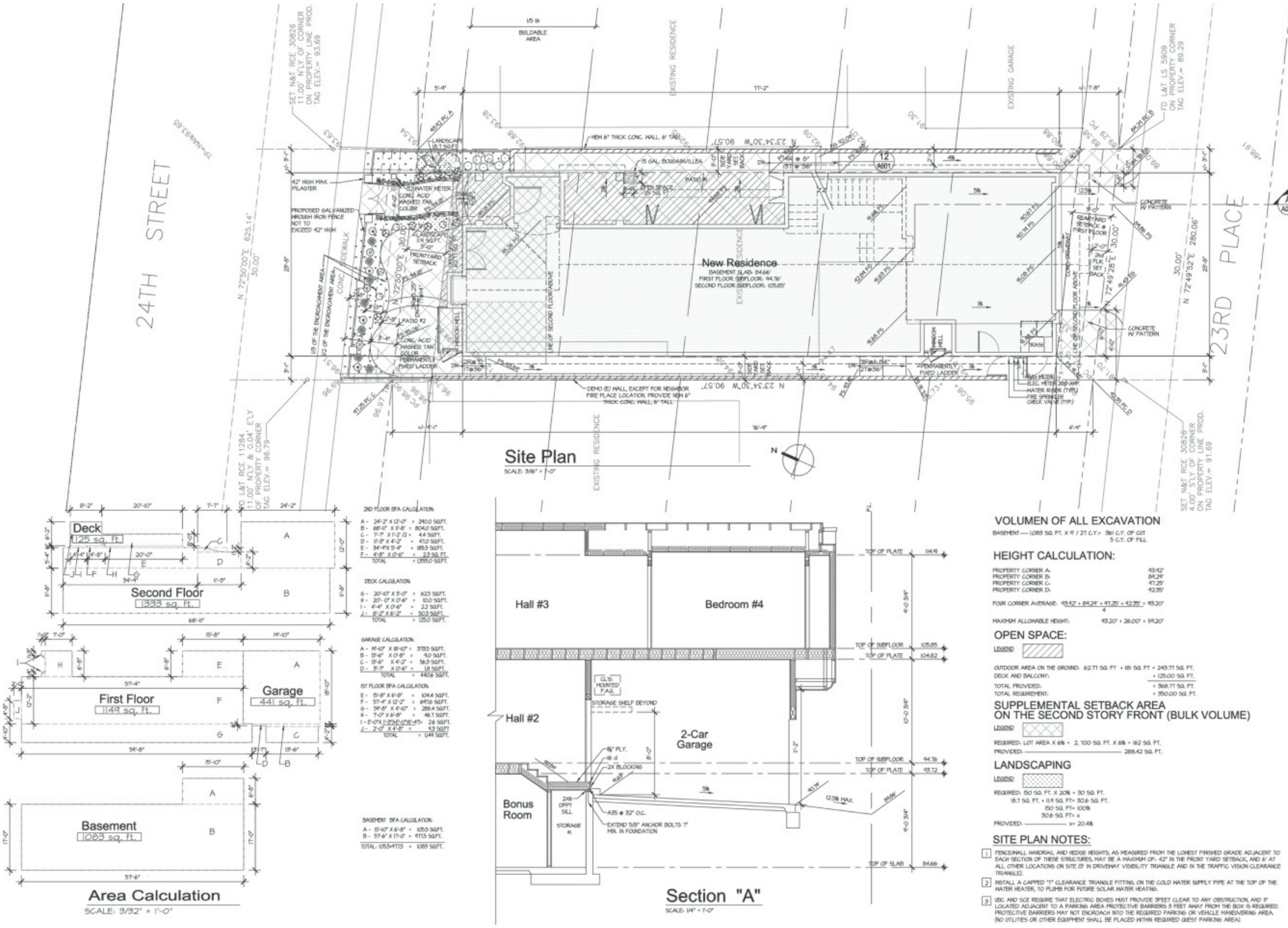


Figure 7.42 Site improvement plan.

(Courtesy of Mr. & Mrs. Givens.)

Site plans for large sites, such as multiple…resident housing projects, must show primary information, such as utility locations, driveway locations, and building locations. Further examples of site development plans appear in later chapters. See Figure 7.43 for a site plan checklist. See Figure 7.44 for a finished example.

1. Vicinity Map / Location Map
2. Property lines
   a. Lengths—each side
   b. Correct angles noted
   c. Direction of angle noted
3. Adjoining streets, sidewalks, parking, curbs, parkways, parking areas, wheel stops, lanes and lighting, trees
4. Existing structures, buildings, alleys, and trees
5. Structures and buildings to be removed / to remain
   a. Trees / Landscape
   b. Old foundations / Walls
   c. Walks / Patios
   d. Miscellanea
6. Public utilities locations
   a. Storm drain
   b. Sewer lines
   c. Gas lines
   d. Gas meter
   e. Water lines
   f. Water meter
   g. Power line
   h. Power pole
   i. Electric meter
   j. Telephone pole
   k. Lamp post
   l. Fire plugs
   m. Fire alarms
   n. Determine overhead / underground
7. Public utilities easements if on property
8. Grading and drainage plan
   a. Existing grade—dotted line
   b. Finish cut or fill—solid line
   c. Legend
   d. Slopes to street
   e. Slopes away from building
9. Grade elevations
   a. Finish slab or finish floor
   b. Corners of building (finish)
   c. Top of all walls
   d. Amount of slope for drainage
10. Roof plan
   a. Building—hidden line
   b. Roof overhang—solid line
   c. Garage located
   d. Slopes (arrows)
   e. Projecting canopies
   f. Slabs and porches
   g. Projecting beams
   h. Material for roof
   i. North arrow
   j. Title and scale
   k. Show ridges and valleys
   l. Roof drains and downspouts
   m. Parapets
   n. Roof jacks for TV, telephone, electric service
   o. Note building outline
   p. Dimension overhangs
   q. Note rain diverters
   r. Sky lights
   s. Roof accessways
   t. Flood lite locations
   u. Service pole for electrical
11. New construction
   a. Retaining walls
   b. Driveways and aprons
   c. Sidewalks
   d. Pool locations and size
   e. Splash blocks
   f. Catch basins
   g. Curbs
   h. Patios, walls, expansion joints, dividers etc.
12. North arrow (usually pointing up)
13. Dimensions
   a. Property lines
   b. Side yards
   c. Rear yards
   d. Front yards
   e. Easements
   f. Street center line
   g. Length of fences and walls
   h. Height of fences and walls
   i. Width of sidewalks, driveway, and parking
   j. Utilities
   k. Locations of existing structures
   l. Note floor elevation
   m. Dimension building to property line
   n. Setbacks
14. Notes
   a. Tract no.
   b. Block no.
   c. Lot no.
   d. House no.
   e. Street
   f. City, county, state, county
   g. Owner's name / address / #
   h. Materials for porches, terraces, drives, etc.
   i. Finish grades where necessary
   j. Slope of driveway
   k. Scale (1/8", 1"-30', 1"-20', etc.)
15. Landscape lighting, note switches
16. Area drains, drain lines to street
17. Show hose bibs
18. Note drying yard, clothes line equipment
19. Complete title block
   a. Sheet no.
   b. Scale
   c. Date
   d. Name drawn by
   e. Project address
   f. Approved by
   g. Sheet title
   h. Revision box
   i. Company name and address (school)
   j. Date printed

[Figure 7.43](#) Sample site plan checklist.

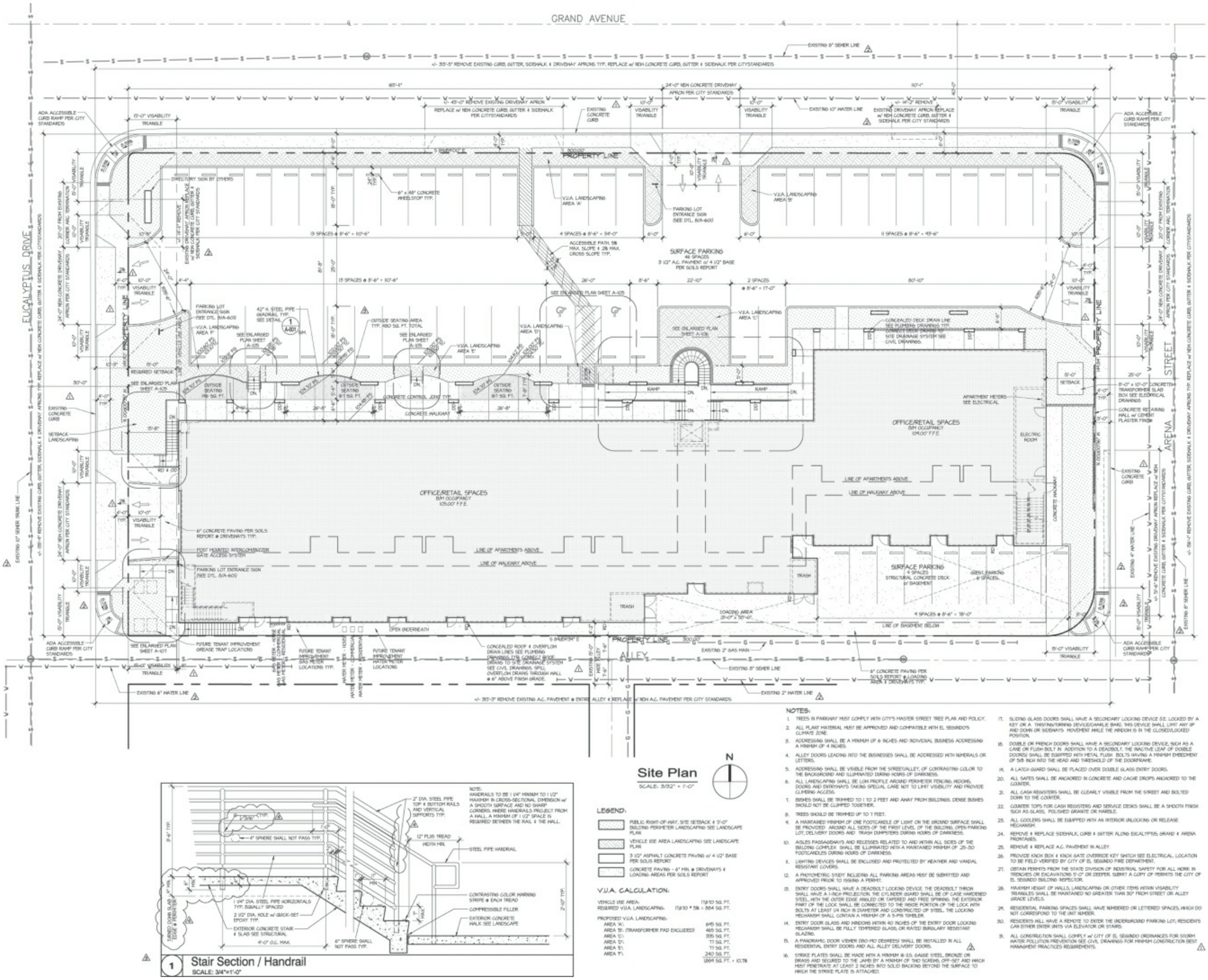


Figure 7.44 Commercial site plan.

Key Terms

- area drains
- bearing capacity
- bearings
- bio…filters
- boring log
- building footprint
- building pad
- catch basin

compacted
contour lines
coordinates
cross…section
cross…slope
cut
daylight grade elevation
dedications
drainage plan
erosion control plan
existing contours
fill
finish grading
finished grades
floor area ratio (FAR)
french drain
geological investigations
geology
hardscape
location plan
lot line
man…made features
metes and bounds
offsets
point of beginning (P.O.B.)
plant list
plat map
plot plan
redevelopment districts
section line
setbacks

site analysis

site plan

slope ratios

soil type

soils and geology map

soils investigations

sub…drain

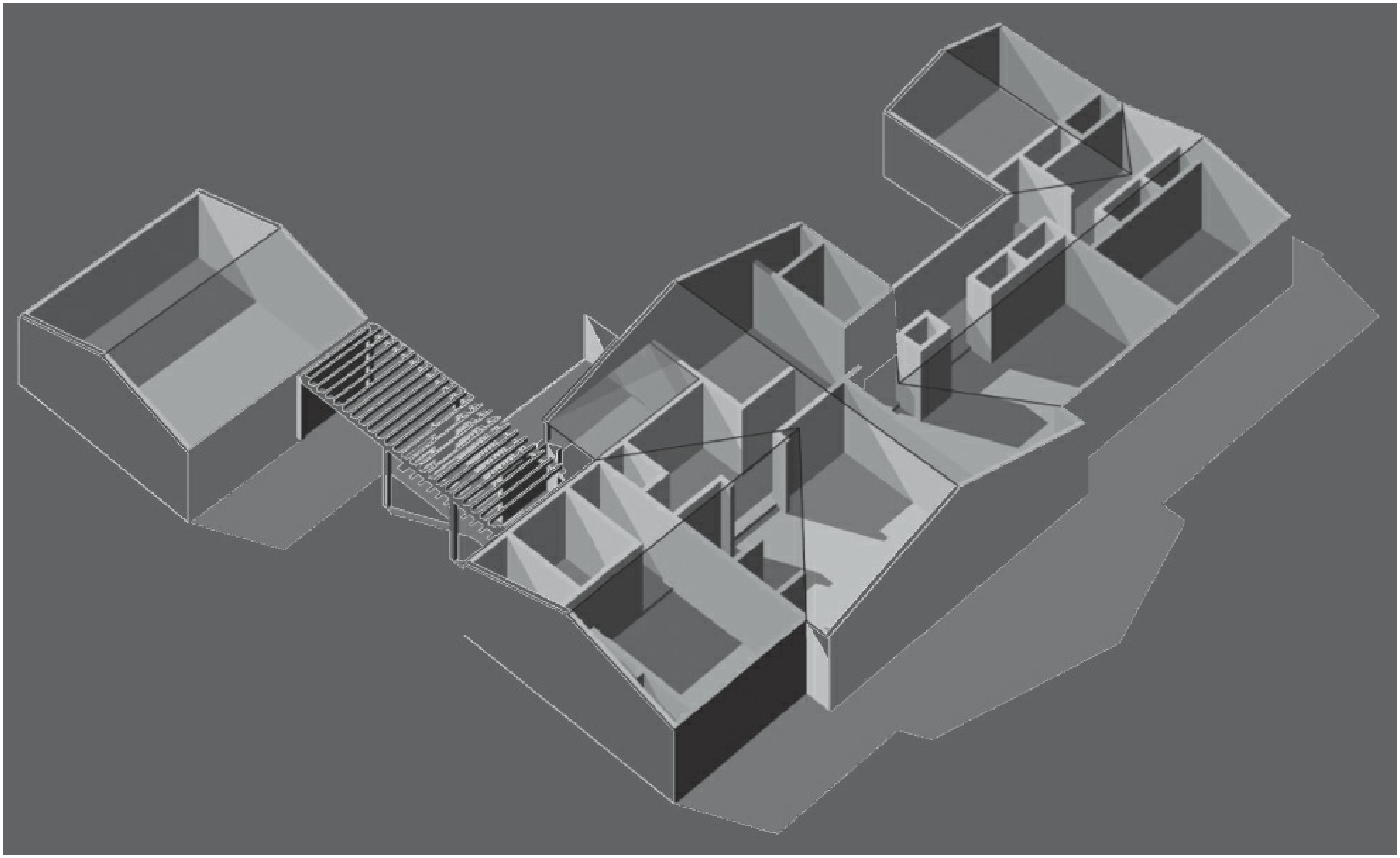
swale

topography map

vicinity map

zoning

Chapter 8
FLOOR PLAN



FLOOR PLANS

Definition

The point of reference for working drawings is the floor plan: a drawing viewed from above with the roof removed. Actually, it is a horizontal cut (section) taken at approximately eye level. See Figure 8.1.

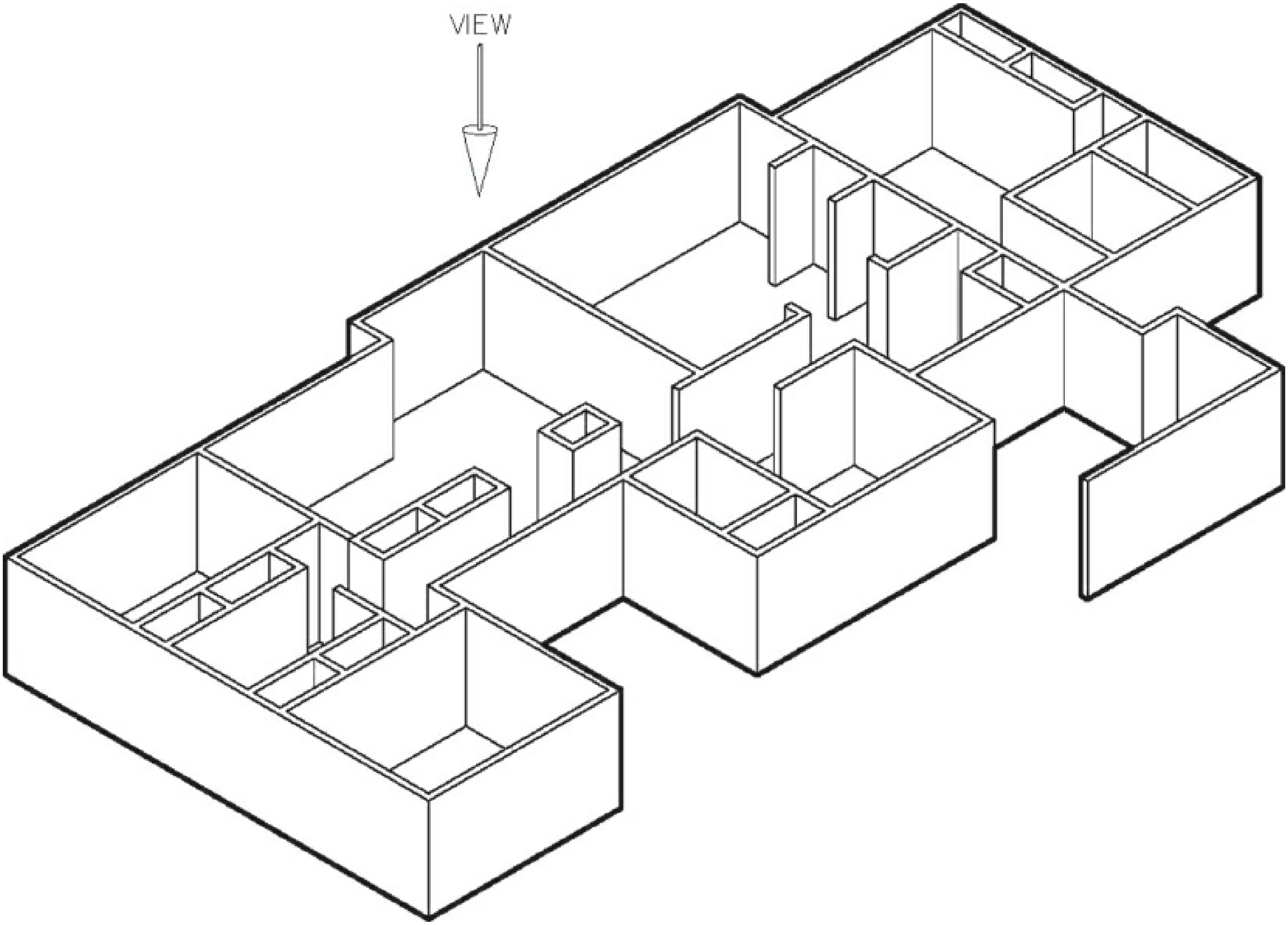


Figure 8.1 Cutaway pictorial floor plan.

To better understand this, imagine a knife slicing through a structure and removing the upper half (on a single…story structure, the half with the roof). The remaining half is then viewed from the air. This becomes the floor plan. See Figure 8.2.

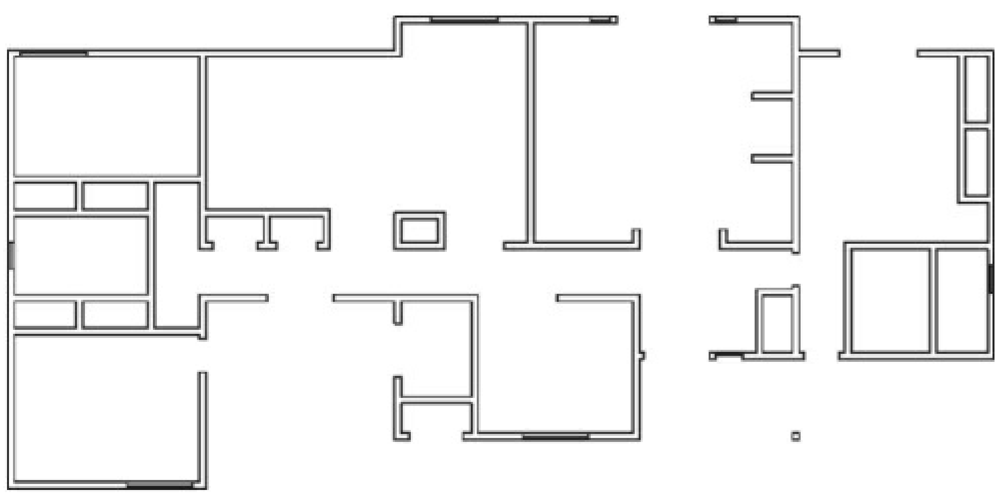


Figure 8.2 Floor plan.

Single… and Split…Level Floor Plans

The floor plan for a split…level residence is more complicated. In the following example, the entry, powder room, and garage are at the mid…level, which is also the level of the street and sidewalk. Use this level as a point of reference.

The stairs at the rear of the entry lead to the upper and lower levels. The lower level contains the master bedroom, master bath, study, bedroom, laundry, and bathroom. See Figure 8.3. The upper level contains the living room with a wet bar, and the dining room, kitchen, breakfast room, and foyer. See Figure 8.4. When these are translated into a floor plan, they appear as in Figures 8.5 and 8.6. The mid…level is duplicated and common to both drawings.

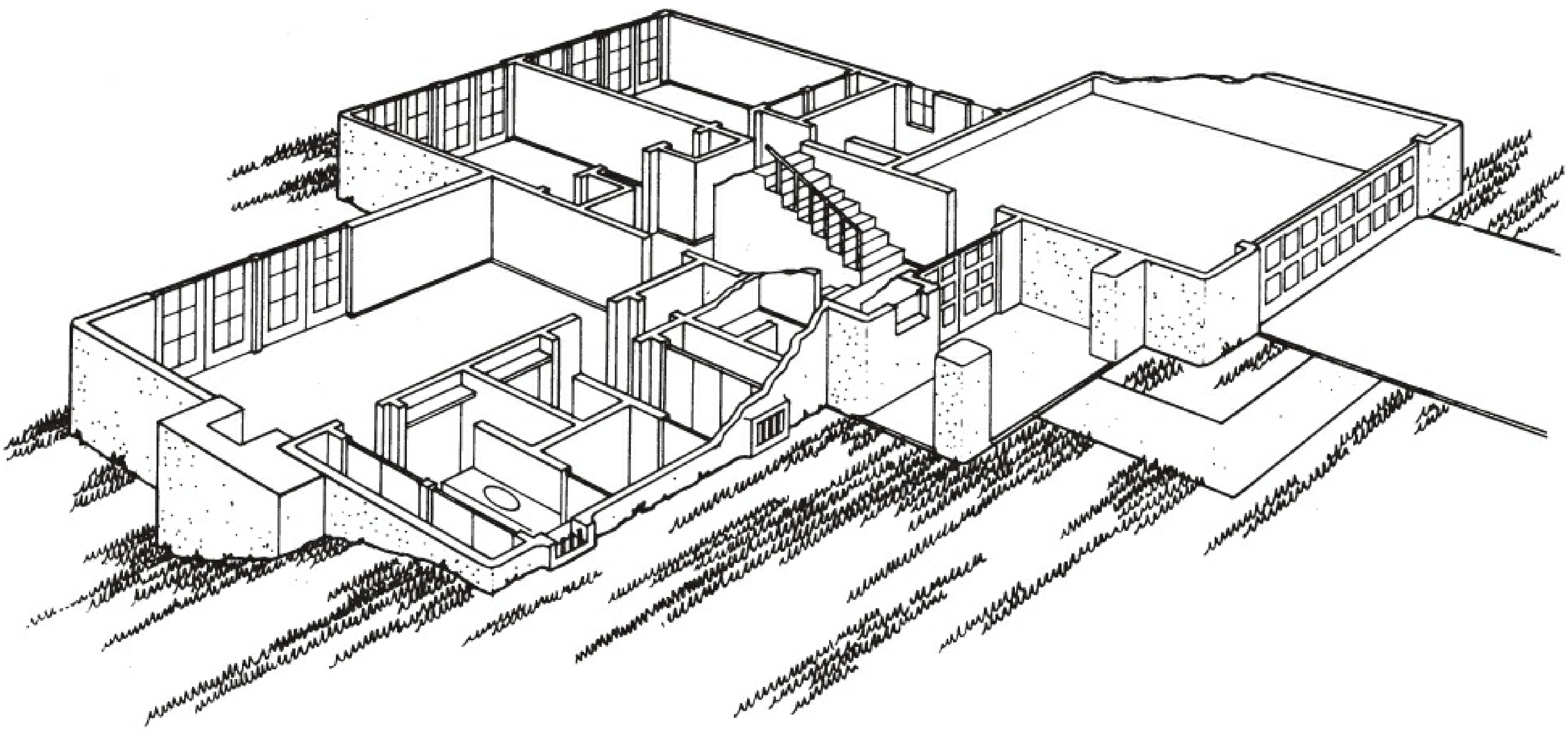


Figure 8.3 Pictorial of lower…level floor plan.

(Courtesy of William F. Smith—Builder.)

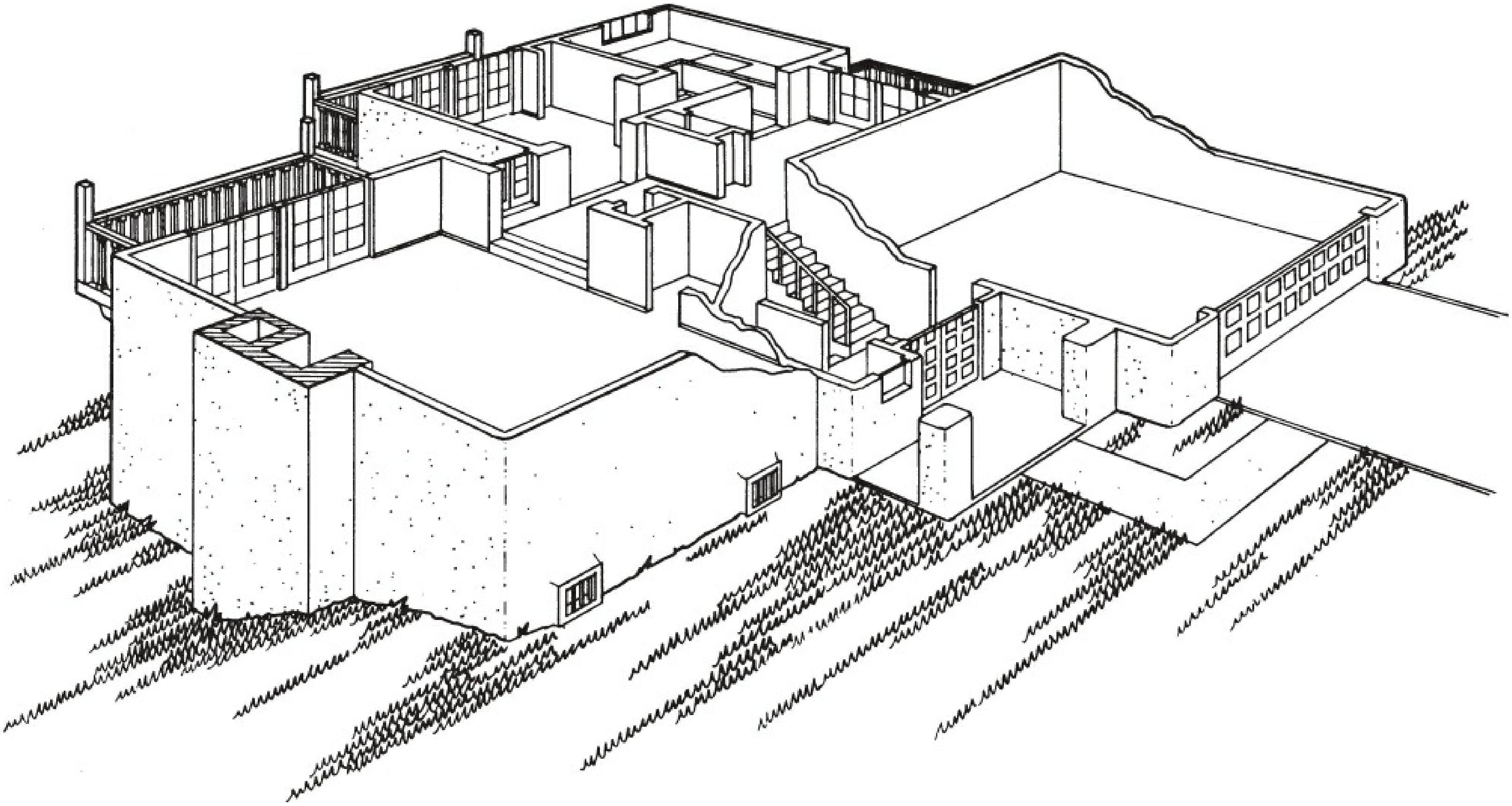


Figure 8.4 Pictorial of upper…level floor plan.

(Courtesy of William F. Smith—Builder.)

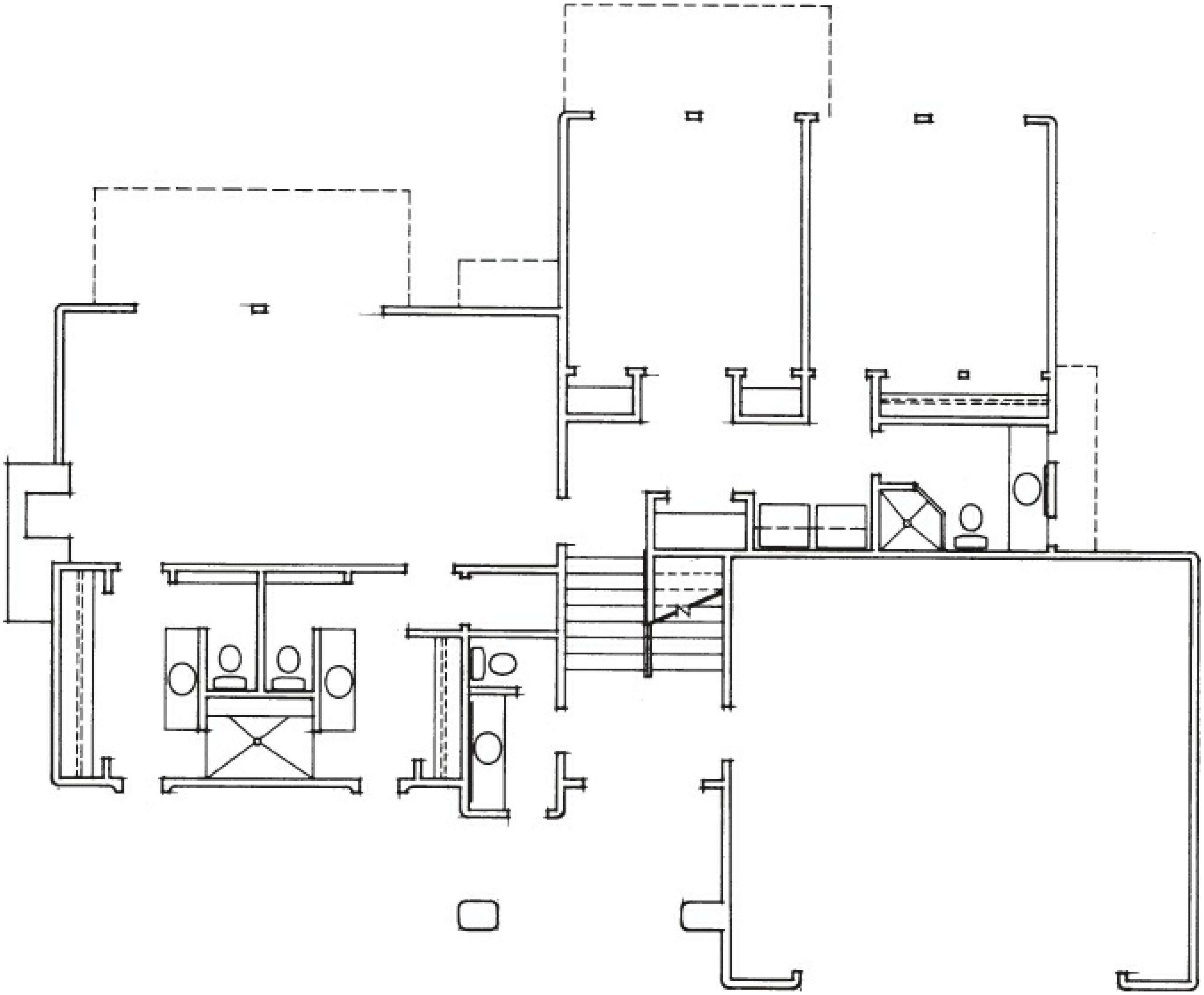


Figure 8.5 Lower…level floor plan.

(Courtesy of William F. Smith—Builder.)

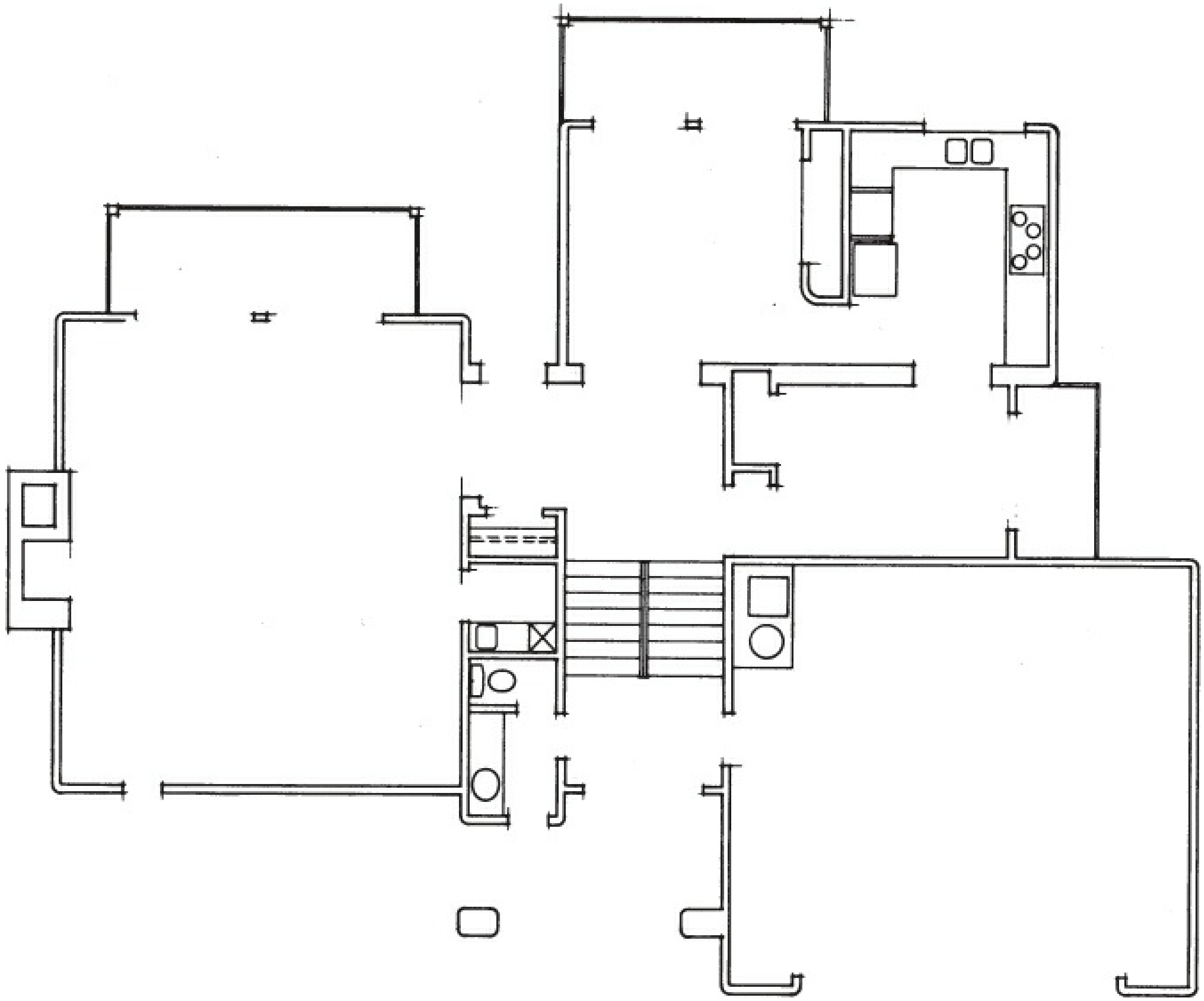


Figure 8.6 Upper…level floor plan.

(Courtesy of William F. Smith—Builder.)

A second approach is to use a **break line** (a line with a jog in it to indicate that a portion has been deleted), showing only a part of the garage on one of the plans. Another approach is to use a straight break line through the garage and draft it showing only part of the garage on one of the plans.

In a two…story building, a single room on the first floor is sometimes actually two stories high. If this room were a living room, for example, it would be treated as a normal one…story living room on the first…floor plan; however, the area would be repeated on the second…floor plan and labeled as upper living room or just labeled “open.”

To simplify the image to be drafted, not every structural member is shown. For example, in a wood…framed structure, if every vertical piece of wood were shown, the task would be impossible. Simplifying this image of the wood structure is done with two parallel lines. Sometimes the insulation is shown in symbol form and is not shown through the total wall. See Figure 8.7. The same parallel series of lines can also be used to represent a masonry wall by adding a series of diagonal lines. See Figure 8.8. Steel frame can be represented as shown in Figure 8.9.

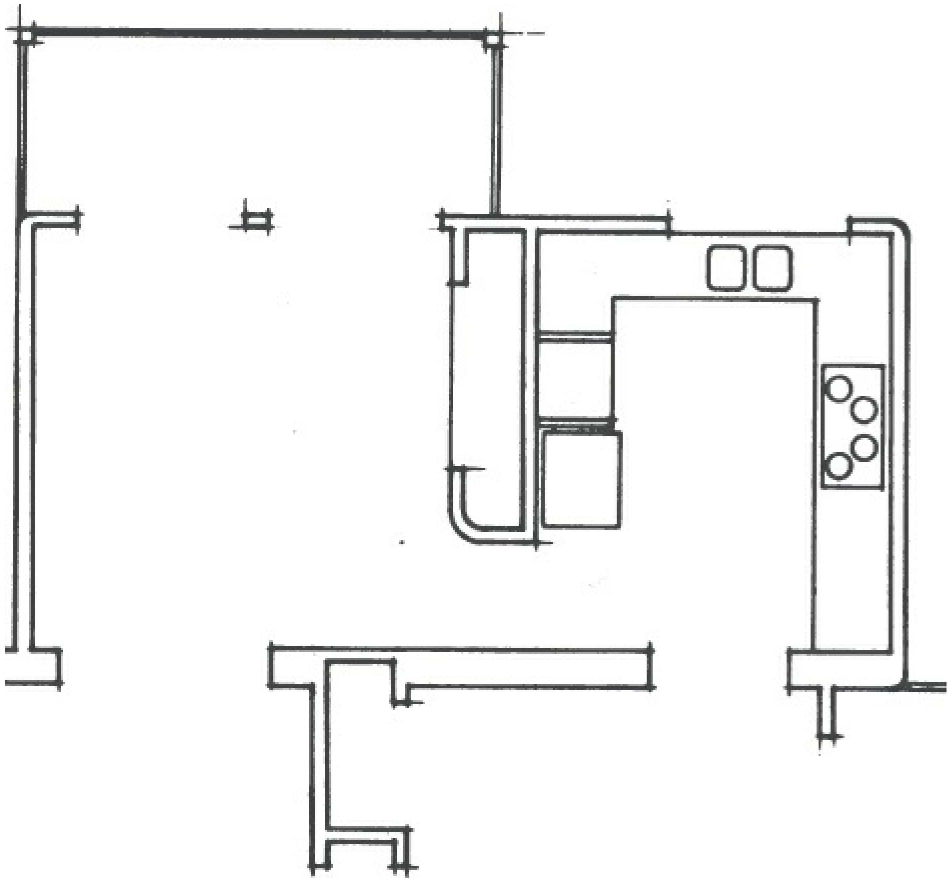


Figure 8.7 Representation of wood frame.

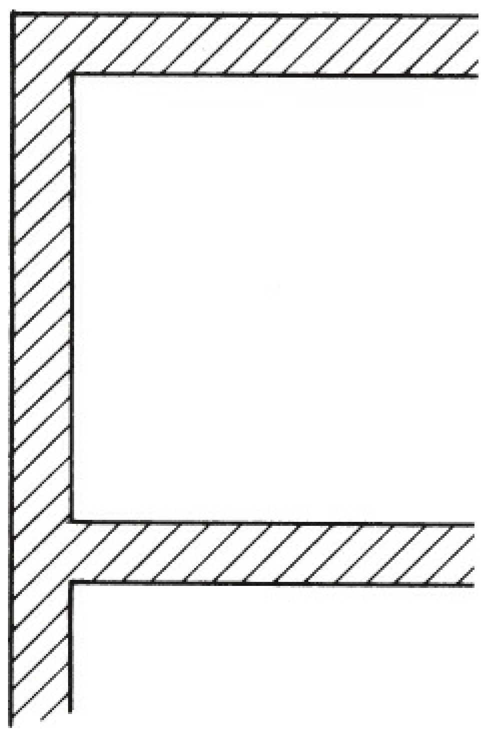


Figure 8.8 Representation of masonry.

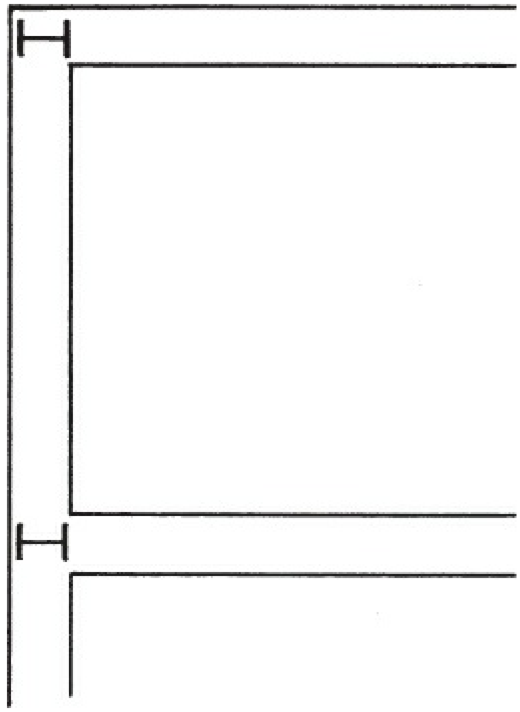


Figure 8.9 Representation of steel frame.

TYPES OF FLOOR PLANS

In order to help you understand how working drawings are created in an office, we will borrow a small one…story wood, a structure built with masonry, and a structure built of steel as the primary material and wood as a secondary material. All the design stages and final working drawings can be found in Chapters 16 through 18 in Section III of this book.

Wood Framing

Figure 8.10 shows the appearance of a corner of a wood…frame structure. Each side of the wall is built separately. An extra stud is usually placed at the end of the wall; it extends to the edge of the building. It therefore acts as a structural support and gives a larger nailing surface to which wall materials can be anchored.

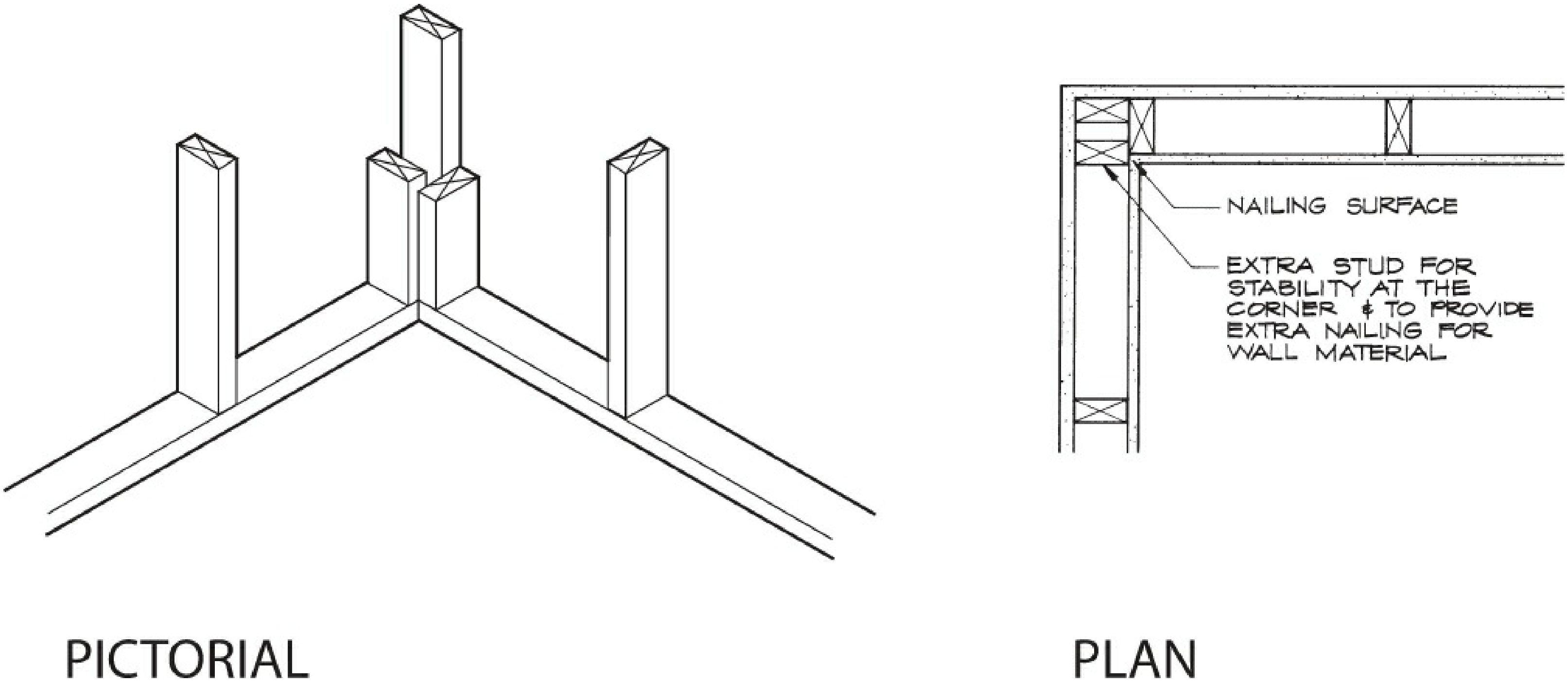


Figure 8.10 Corner at sill.

Figure 8.11 shows the pictorial intersection of an interior wall and an exterior wall, and a plan view of that same intersection.

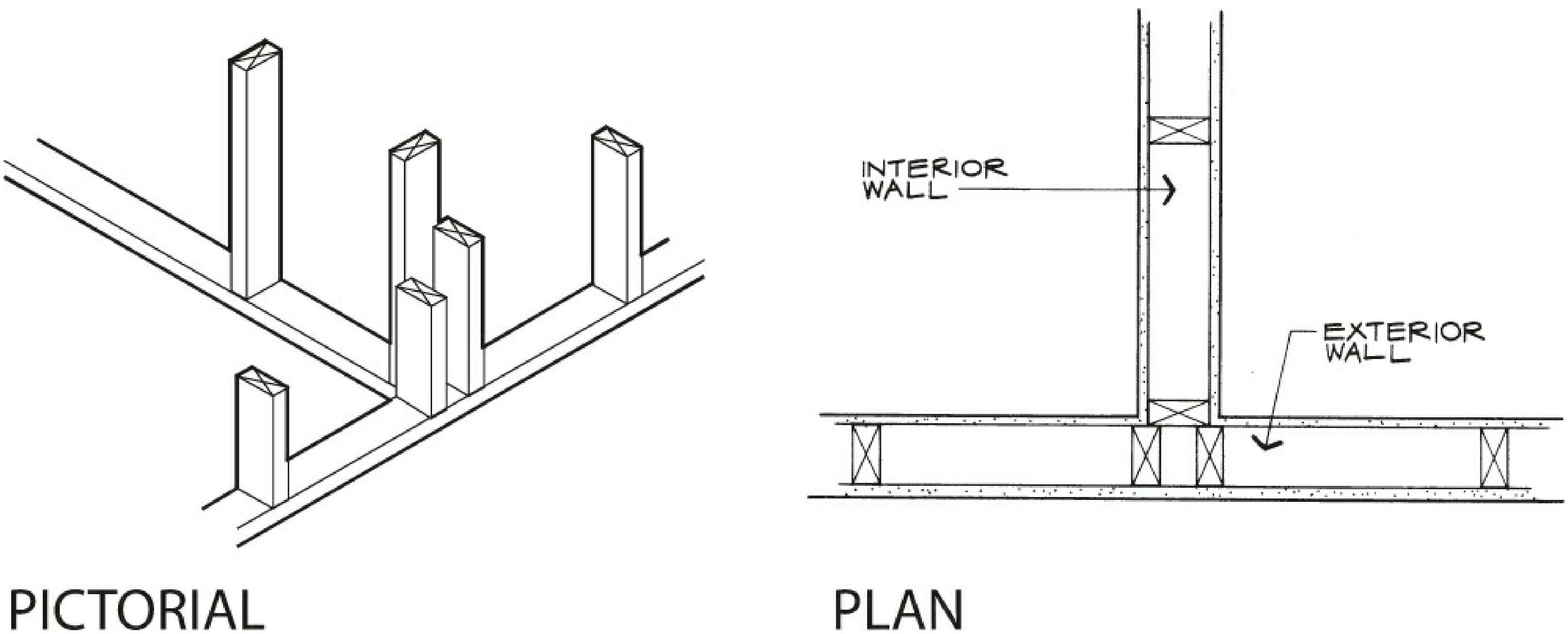


Figure 8.11 Intersection of exterior wall in interior wall.

Walls are not the only important elements in the framing process, of course. You must also consider the locations of doors and windows and the special framing they require. See Figure 8.12.

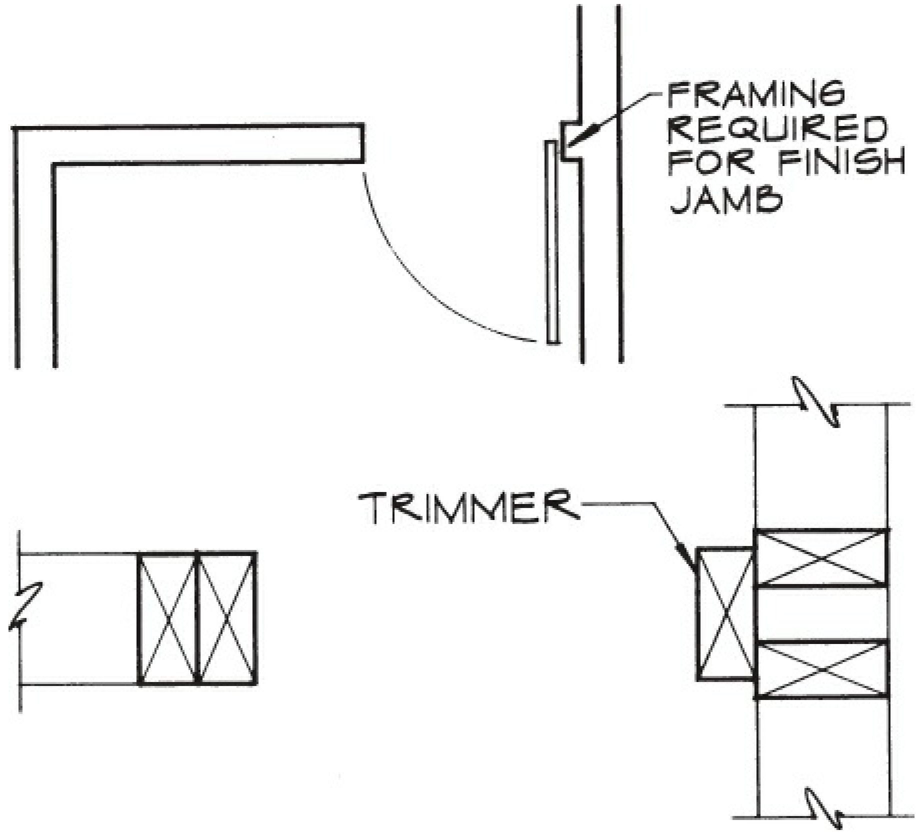


Figure 8.12 Framing for a door.

Interior Dimensioning. Because a wood…framed wall is a built…up system—that is, a wall frame of wood upon which plaster or another wall covering is added—dimension lines must sometimes be drawn to the edge of studs and sometimes to their center.

Figure 8.13 shows how the corner of a wood…framed wall is dimensioned to the stud line. Figure 8.14 shows how an interior wall intersecting an exterior wall is dimensioned. It is dimensioned to the center so that the two studs that the interior wall will join can be located.

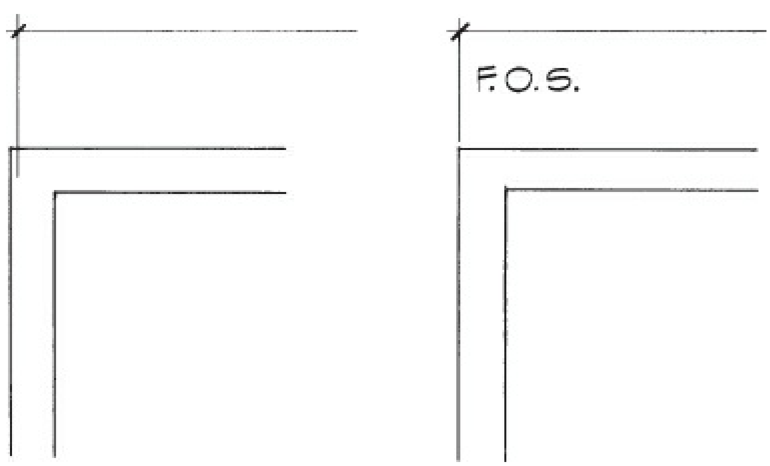


Figure 8.13 Dimensioning corners.

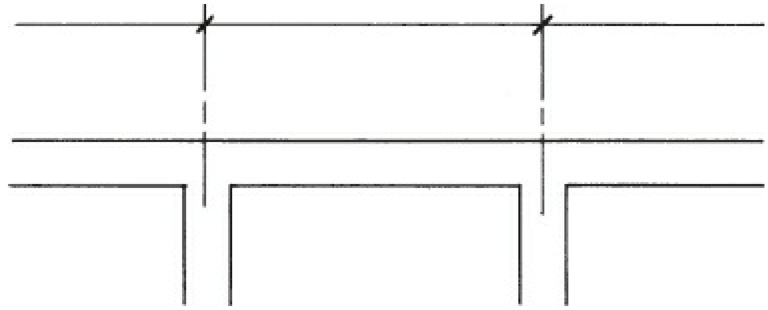


Figure 8.14 Dimensioning interior walls.

The process of drawing each stud in a wall becomes tiresome. So, usually, two lines drawn 6″ apart (in scale) are used to represent wood. To make sure that the person reading this set of plans knows that the stud is being dimensioned and not the exterior surface, the extension is often brought inside the 6″…wide wall lines. Another way to make this clear is to take extension lines to the outside surface and write **face of stud (F.O.S.)** adjacent to the extension lines. See Figure 8.13.

Dimensioning interior walls requires a centerline or an extension line right into the wall intersection, as shown in Figure 8.14. A centerline is more desirable than a solid line.

Windows and doors are located to the center of the object, as shown in Figure 8.15. When a structural column is next to a window or door, the doors and windows are dimensioned to the structural column. The size of a particular window or door can be obtained from a chart called a *schedule*. This schedule can be found by locating the sheet number on the bottom half of the **reference bubble** adjacent to the window or door. See Figure 8.16. (A reference bubble is a circle with a line drawn through it horizontally.)

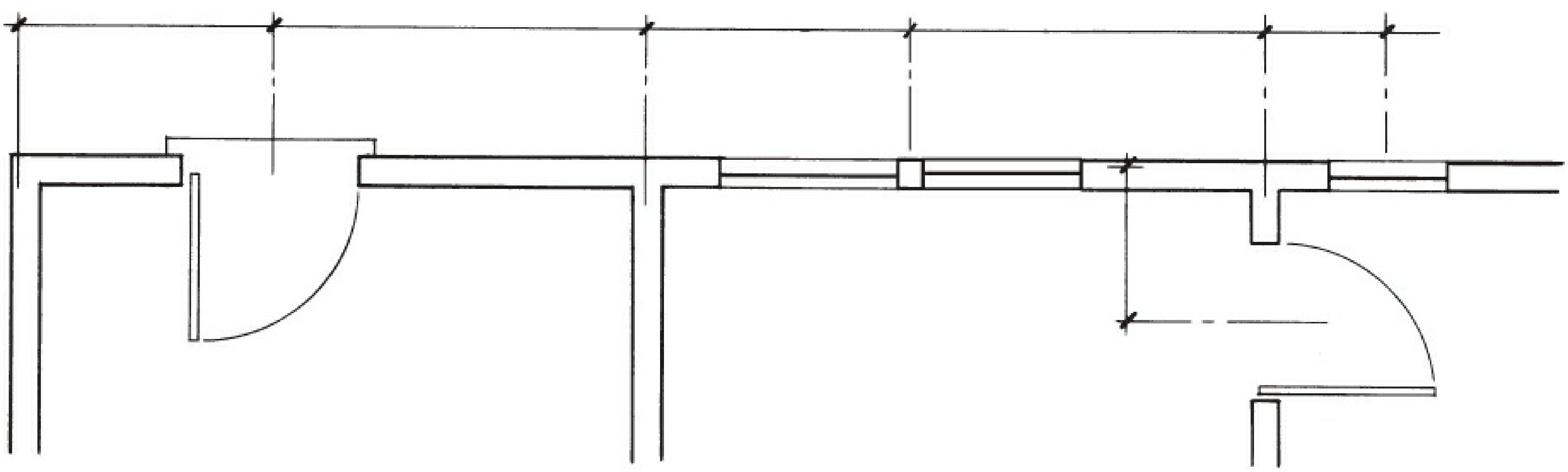


Figure 8.15 Dimensioning doors and windows.

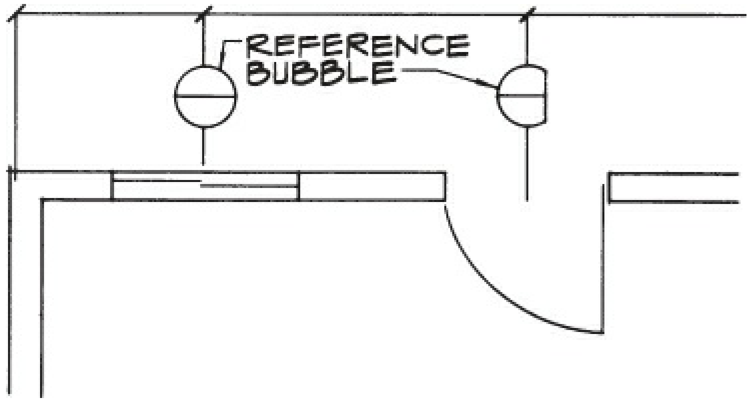


Figure 8.16 Use of reference bubbles on doors and windows.

Exterior Dimensioning. Normally, three to four dimension lines are needed on an exterior dimension of a floor plan. The first dimension line away from the object includes the walls, partitions, centers of windows and doors, and so forth. See Figure 8.17. The second dimension line away from the object (floor plan) includes walls and partitions only. If, in establishing the second dimension line, you duplicate a dimension, eliminate the dimension line closest to the object. The third dimension line away from the object is for overall dimensions. The first dimension line away from the structure should be measured 3⁄4″ to 1½″ from the outside lines of the plan to allow for notes, window and door reference bubbles, equipment that may be placed adjacent to the structure, and so on. The second dimension line away from the structure should be approximately 3⁄8″ to ½″ away from the first dimension line. The distance between all subsequent dimension lines should be the same as the distance between the first and second dimension lines.

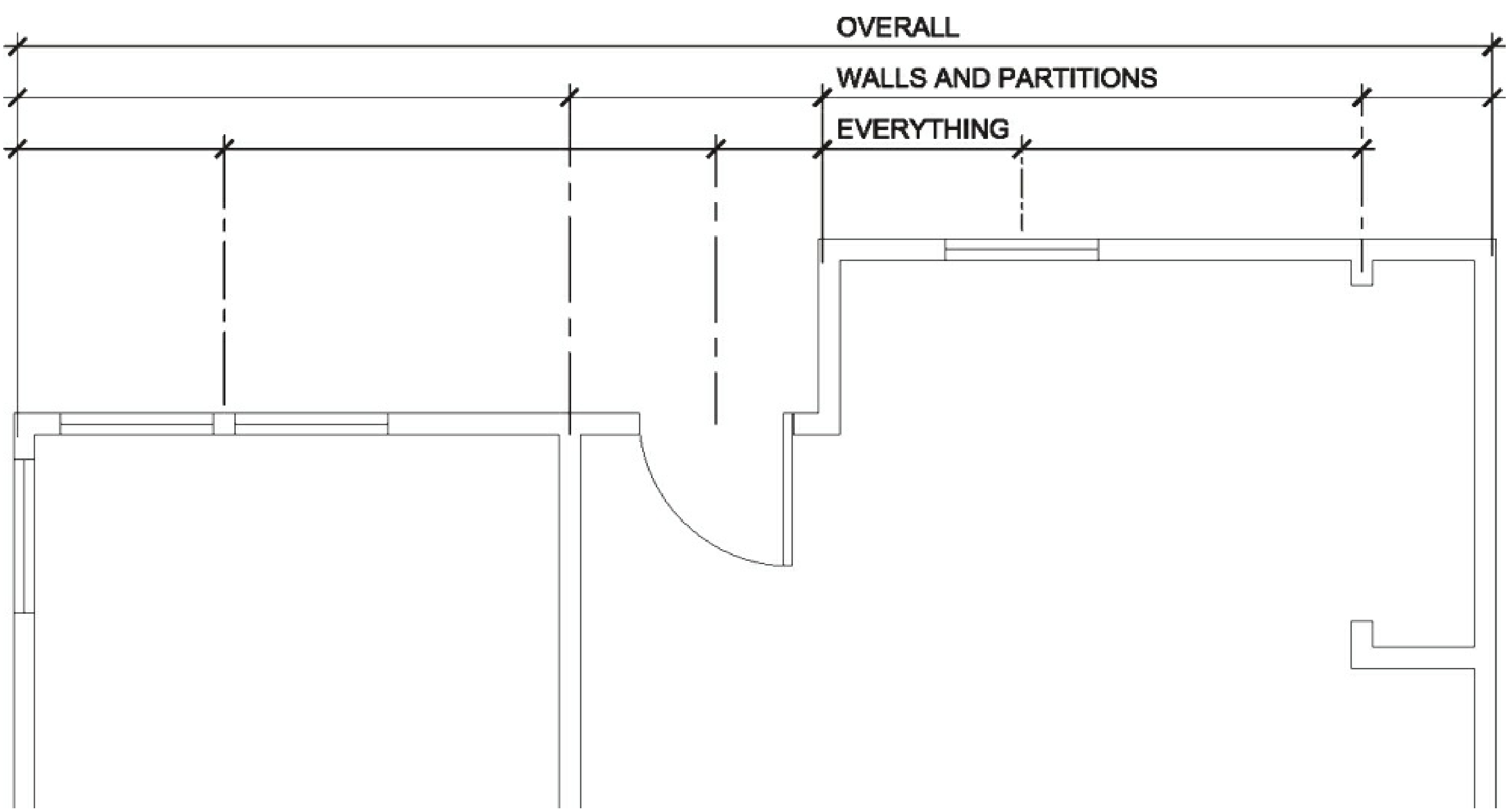


Figure 8.17 First dimension line away from the object.

A large jog in a wall is called an **offset**. Because the jog is removed from the plane that is being dimensioned, you must decide whether to use long extension lines or to dimension the offset at the location of the jog.

If the jog were lengthy, it would be better to dimension the jog on its own. See Figure 8.18 for a small jog. This would be dimensioned on the second or third dimension line, and the fourth dimension line would become the overall.

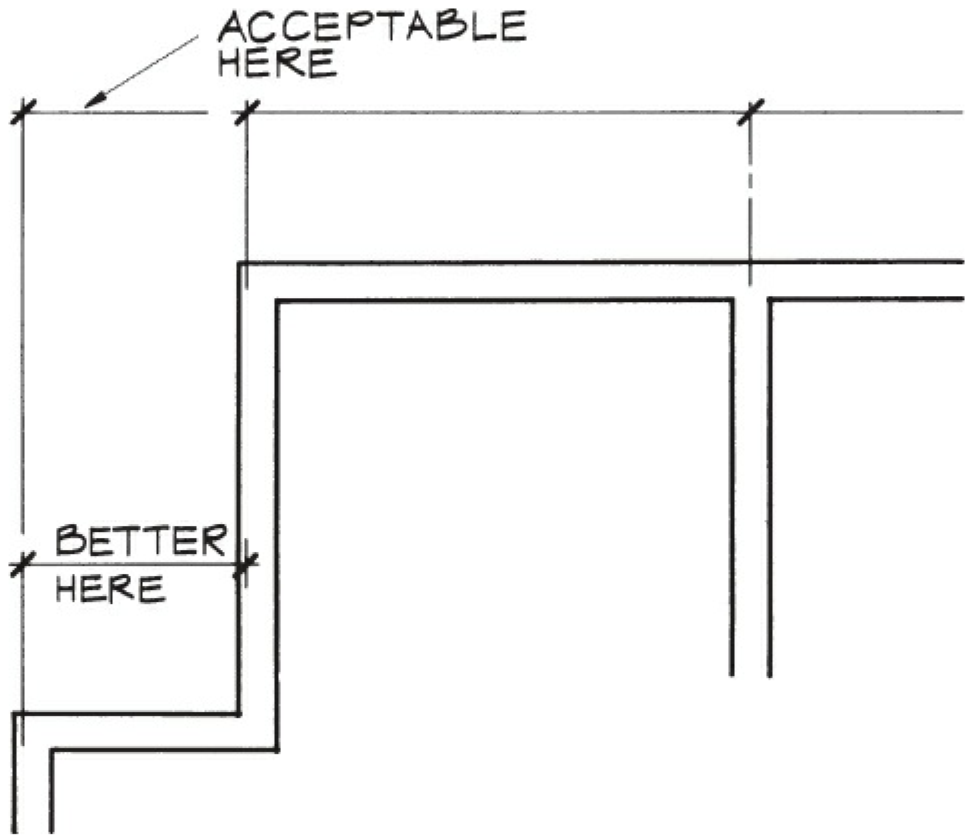


Figure 8.18 Offset dimension locations.

Objects located independently or outside of the structure, such as posts (columns), are treated differently. First, the order in which the items are to be built must be established. Will the columns be built before or after the adjacent walls? If the walls or the foundation for the walls are to be erected first, then major walls near the columns are identified and the columns are located from them. Never dimension from an inaccessible location! See Figure 8.19.

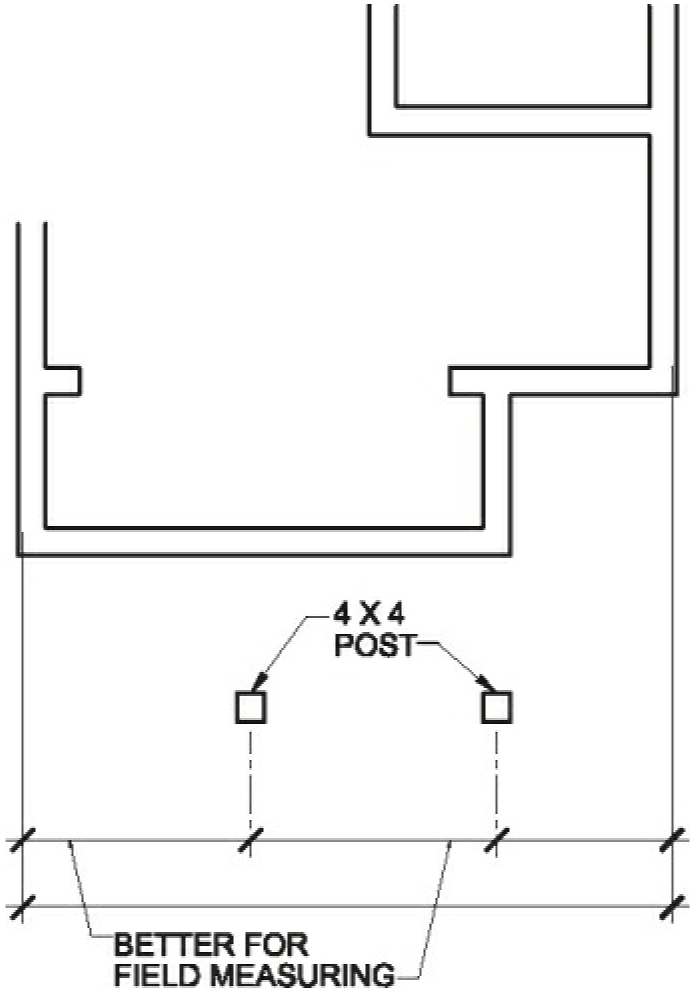


Figure 8.19 Locating columns from the structure.

Masonry/Concrete Block Structures

When walls are built of brick or concrete block instead of wood frame, the procedure changes. Everything here is based on the size and proportion of the masonry unit used. Represent masonry as a series of diagonal lines. See Figure 8.20. Show door and window openings in the same way as you did for wood…framed structures. You may represent concrete block in the same way as brick for small…scale drawings, but be aware that some offices use different material designations. See Figure 8.21. (These methods of representing concrete blocks were obtained from various sources, including association literature, American Institute of Architects [AIA] standards, and other reference sources.) Extension lines for dimensioning are taken to the edge (end) of the exterior surface in both exterior and interior walls. See Figure 8.22.

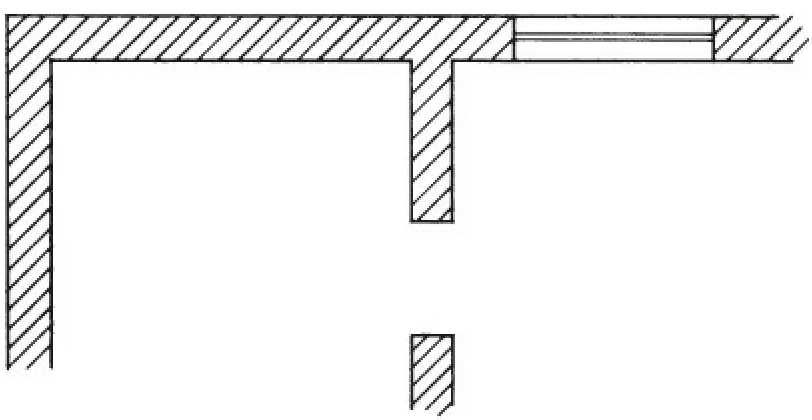


Figure 8.20 Masonry floor plan.

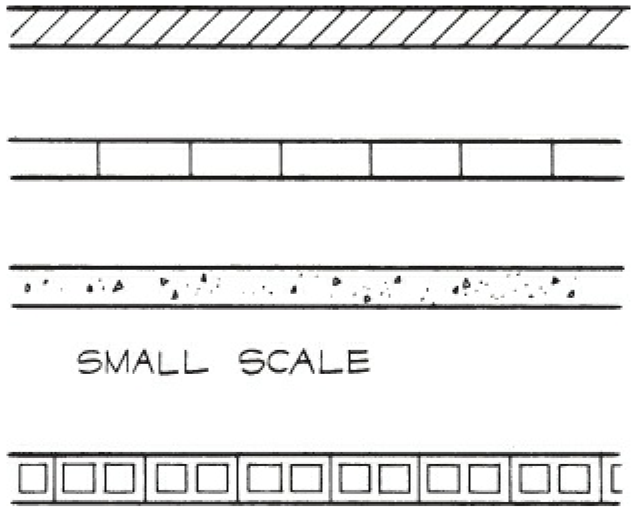


Figure 8.21 Concrete block material designations used on floor plans.

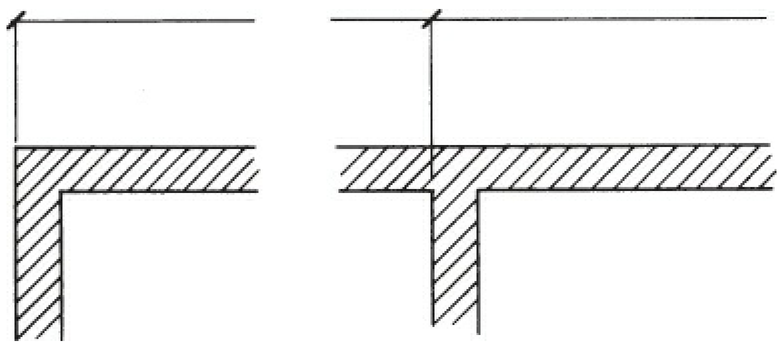


Figure 8.22 Dimensioning masonry walls.

Pilasters, which are columns built into the wall by widening the walls, are dimensioned to the center. See Figure 8.23. The size of the pilaster itself can be lettered adjacent to one of the pilasters in the drawing. Another method of dealing with the size of these pilasters is to refer the reader of the plan to a detail with a note or reference bubble. All columns consisting of masonry or masonry around steel are also dimensioned to the center.

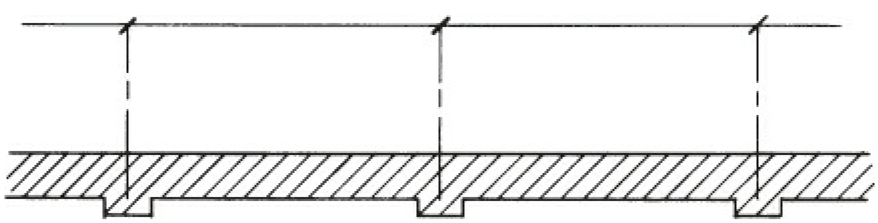


Figure 8.23 Dimensioning pilasters.

Windows and Doors. Windows and doors create a unique problem in masonry units. In wood structures, windows and doors are located by dimensioning to the center and allowing the framing carpenter to create the proper opening for the required window or door size. In masonry, the opening is established before installation of the window or door. This is called the **rough opening**; the final opening size is called the **finished opening**.

The rough opening, which is usually the one dimensioned on the plan, should follow the masonry block module. See Figure 8.24. This block module and the specific type of detail

used determine the most economical and practical window and door sizes. See Figure 8.25. Therefore, you should provide dimensions for locating windows, doors, interior walls, and anything of a masonry variety to the rough opening. See Figure 8.26. A floor plan of a truck wash constructed of masonry is shown in Figure 8.27.

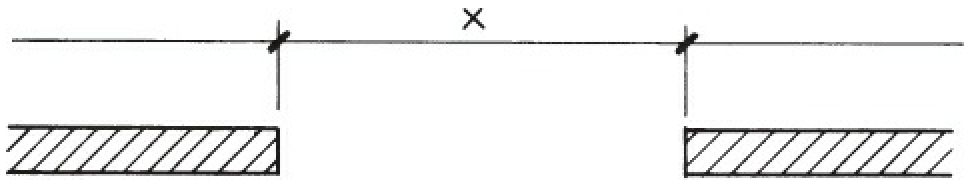


Figure 8.24 Rough opening in masonry wall.

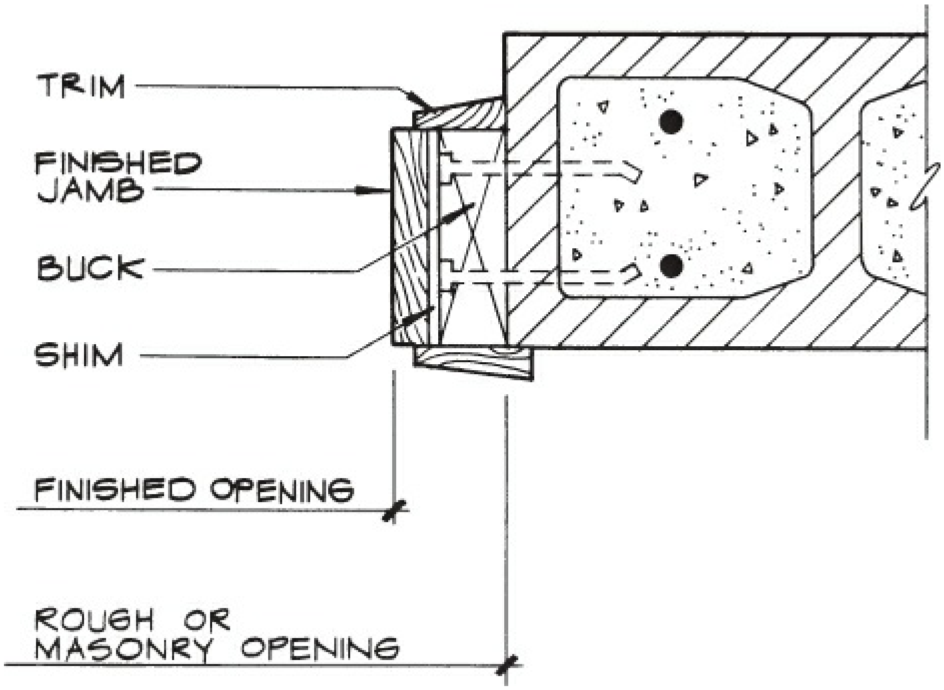


Figure 8.25 Door jamb at masonry opening.

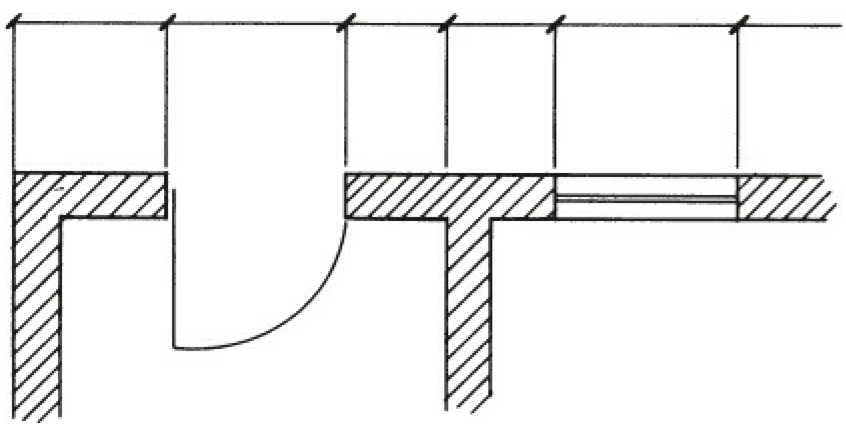
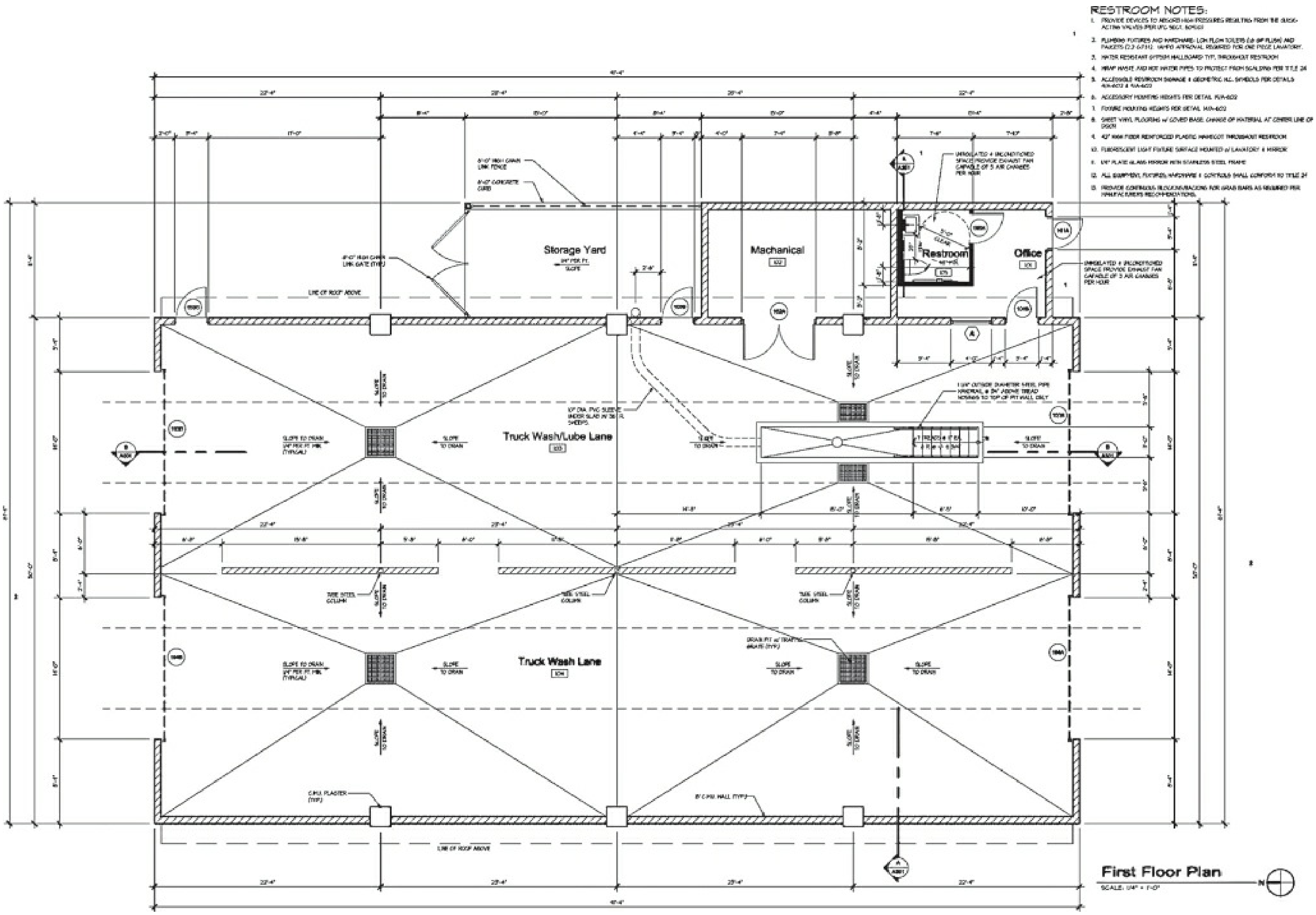


Figure 8.26 Locating doors and windows.



[Figure 8.27](#) Masonry floor plan of a truck wash.

Steel Structures

There are two main types of steel systems: **steel stud** and **steel frame**. Steel studs can be treated like wood stud construction. As with wood stud construction, you need to dimension to the stud face rather than to the wall covering (skin).

There are various shapes of steel studs. See Figure 8.28. Figure 8.29 shows how these shapes appear in the plan view. Drawing each steel stud is time…consuming, so two parallel lines are drawn to indicate the width of the wall. See Figure 8.28A, B, and C. Steel studs can be called out by a note.

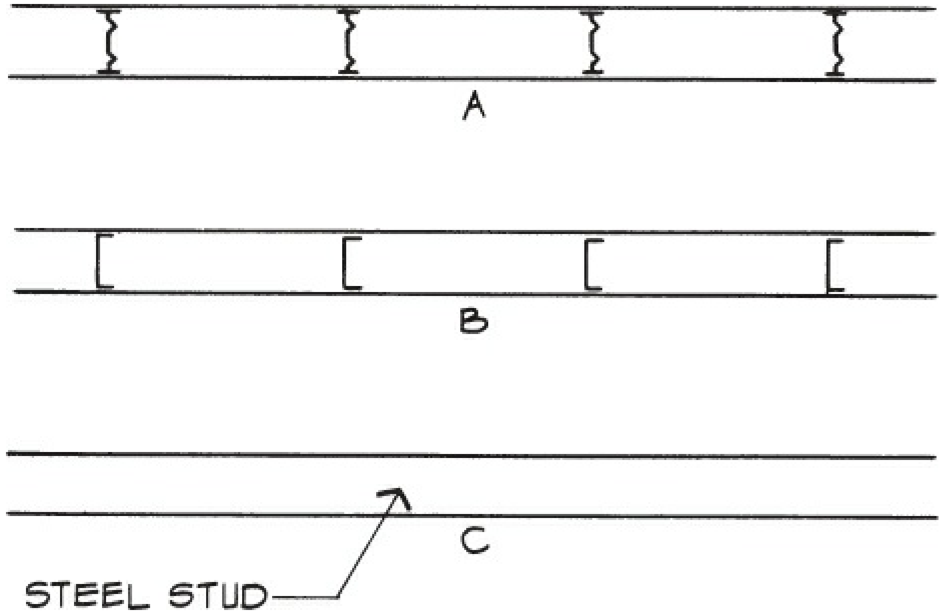


Figure 8.28 Basic steel stud shapes.

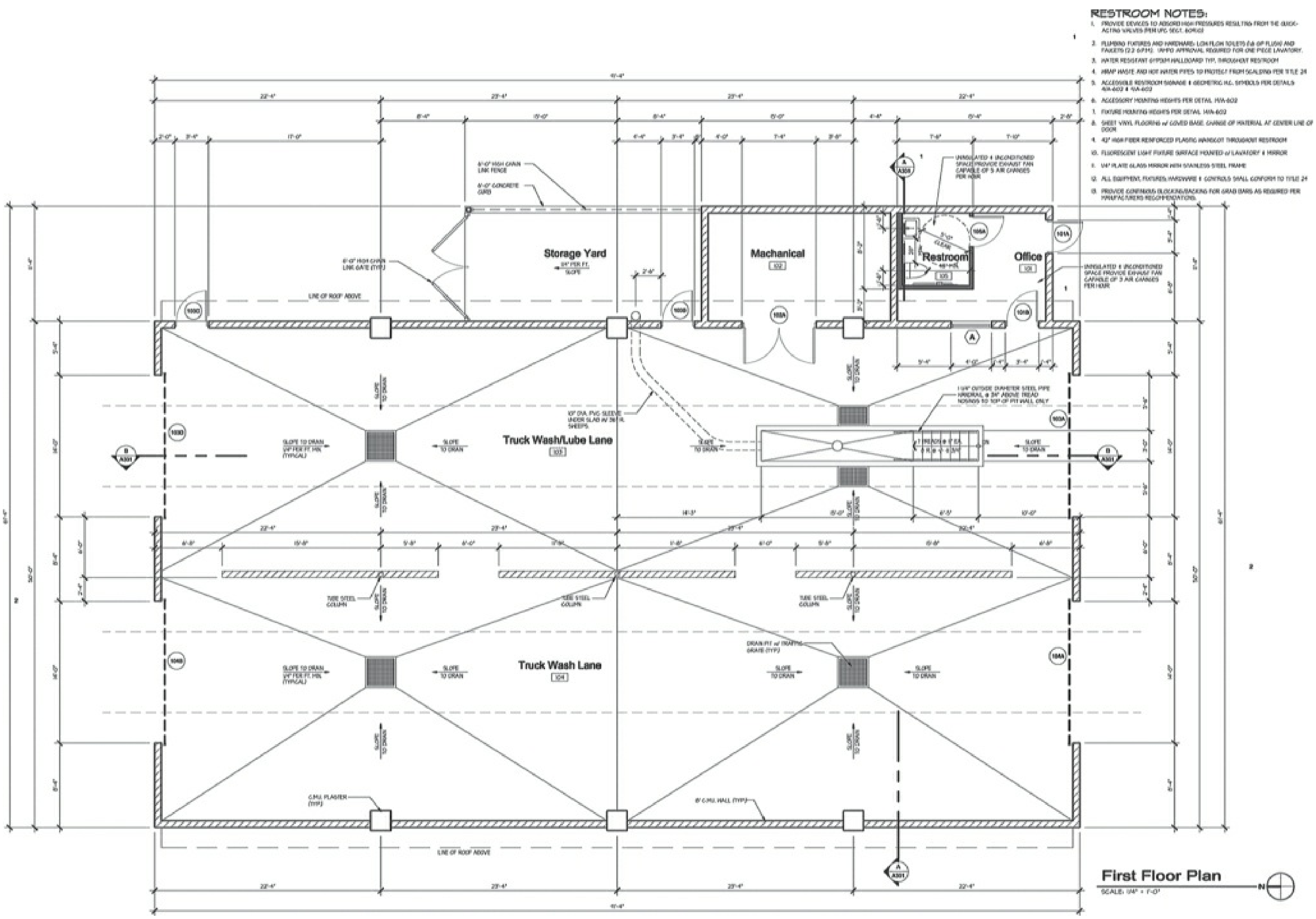


Figure 8.29 Representation of steel studs in a floor plan.

If only a portion of a structure is steel stud and the remainder is wood or masonry, you can shade (*poché*) the area with steel studs or use a steel symbol. See Figure 8.30.

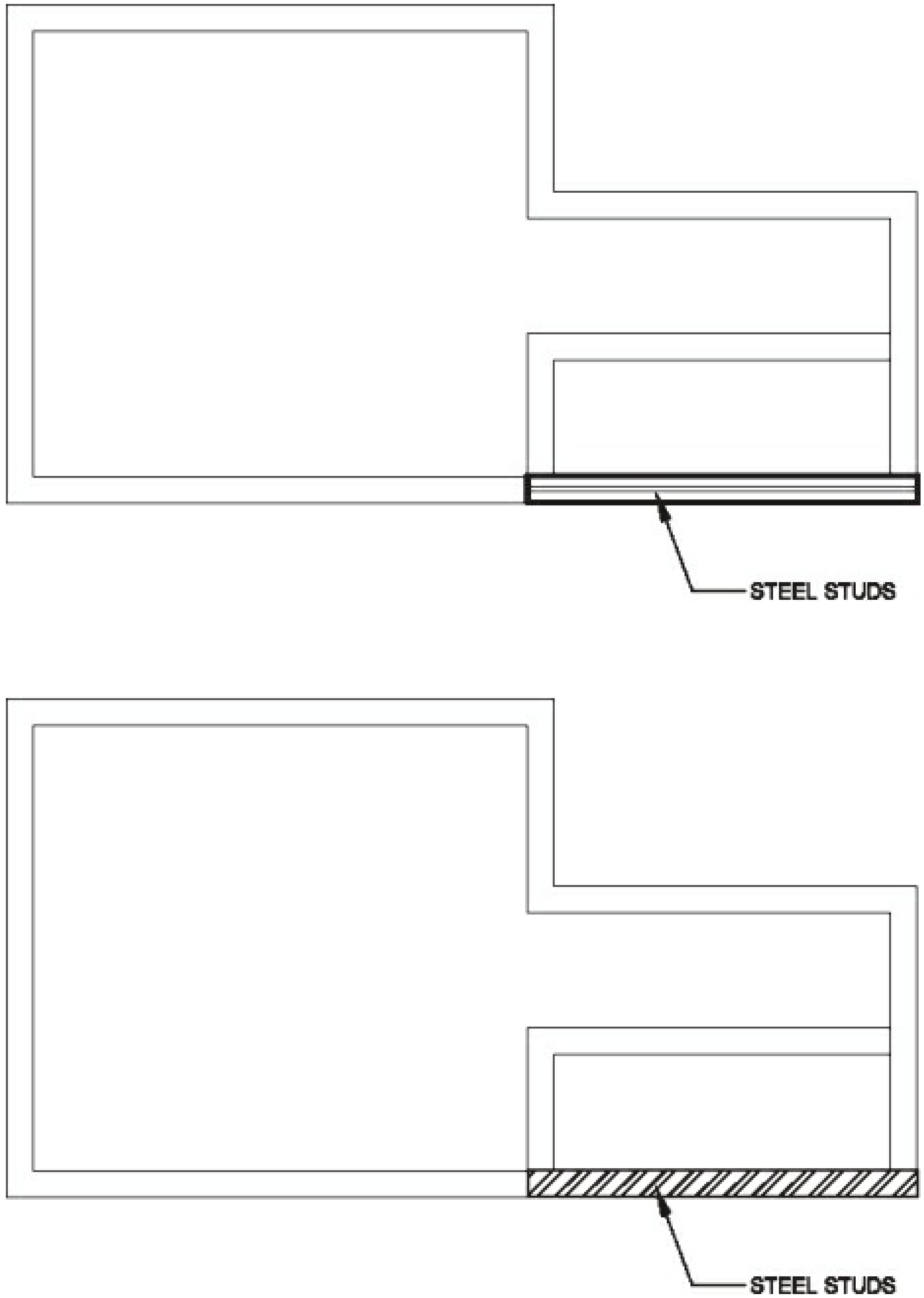


Figure 8.30 Combination of wood and steel.

Dimensioning Columns. Steel columns are commonly used to hold up heavy weights. This weight is distributed to the earth by means of a concrete pad. See Figure 8.31. This concrete pad is dimensioned to its center, as Figure 8.32 shows. When you dimension the steel columns that will show in the floor plan, dimension them to the center. See Figure 8.33. This relates them to the concrete pads. Dimensioning a series of columns follows the same procedure. See Figure 8.34. The dimensions are taken to the centers of the columns in each direction.

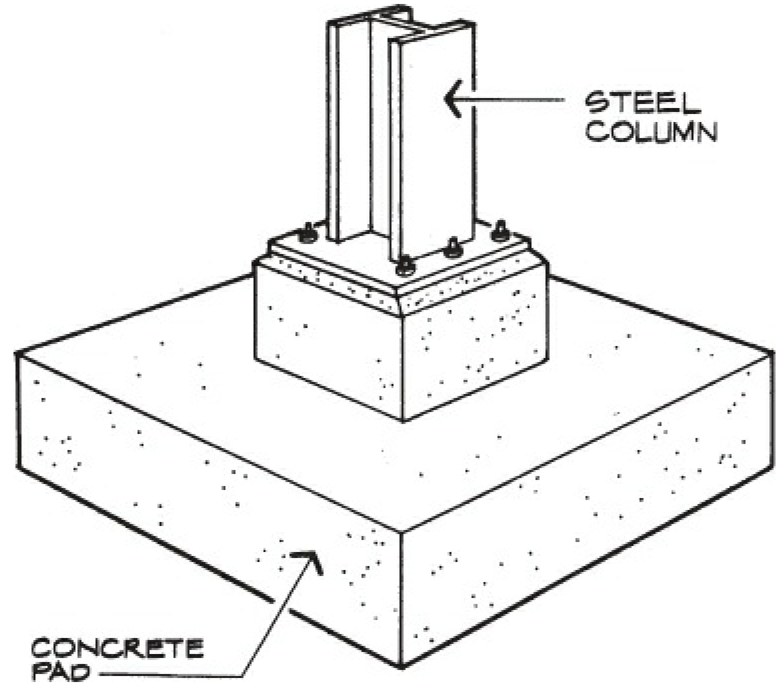


Figure 8.31 Steel column and concrete pad.

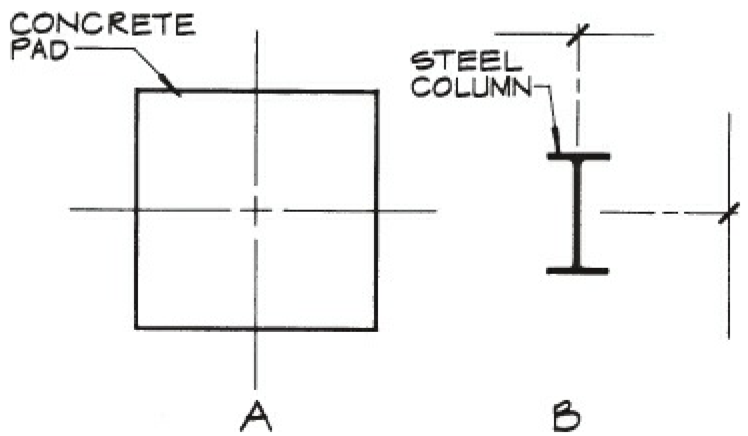


Figure 8.32 Dimensioning concrete pads and steel columns.

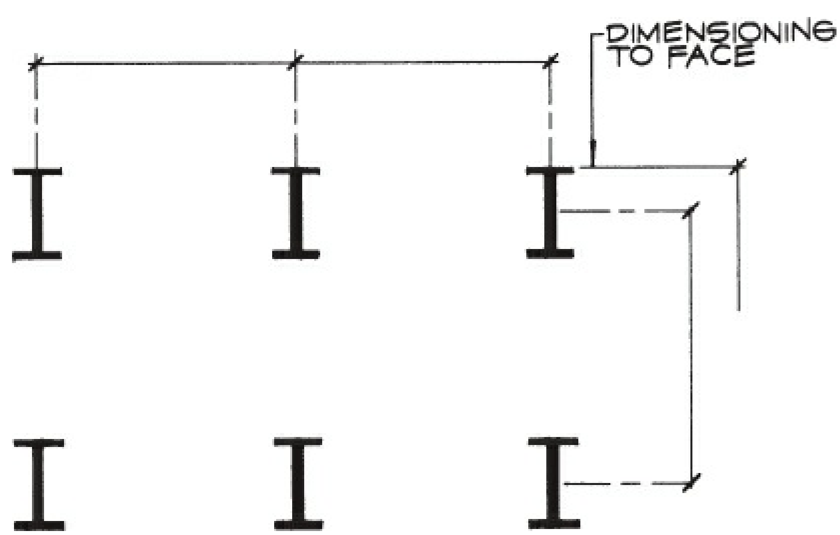


Figure 8.33 Dimensioning a series of columns.

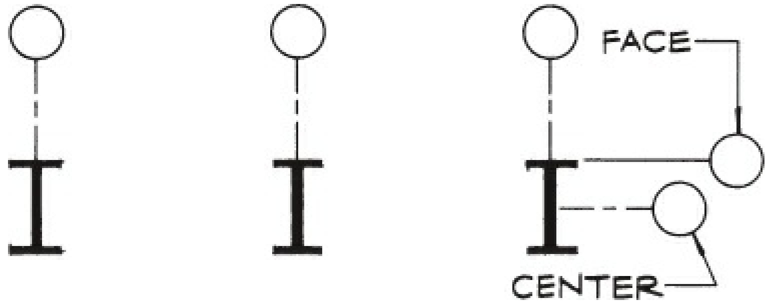


Figure 8.34 Dimensioning a series of columns by way of the axial reference plane.

Sometimes, the column must be dimensioned to the face rather than to the center. As Figure 8.33 shows, the extension line is taken to the outside face of the column. Axial reference planes are often used in conjunction with steel columns, as shown in Figure 8.34, and the column may be dimensioned to the face. (The dimensional reference system was discussed in Chapter 1.) A sample of a portion of a floor plan dimensioned with and without a series of axial reference planes is shown in Figure 8.35A and B. Because of the **grid** pattern often formed by the placement of these columns, a centerline or a plus (+) type symbol is often used to simplify the drawing. See Figure 8.36.

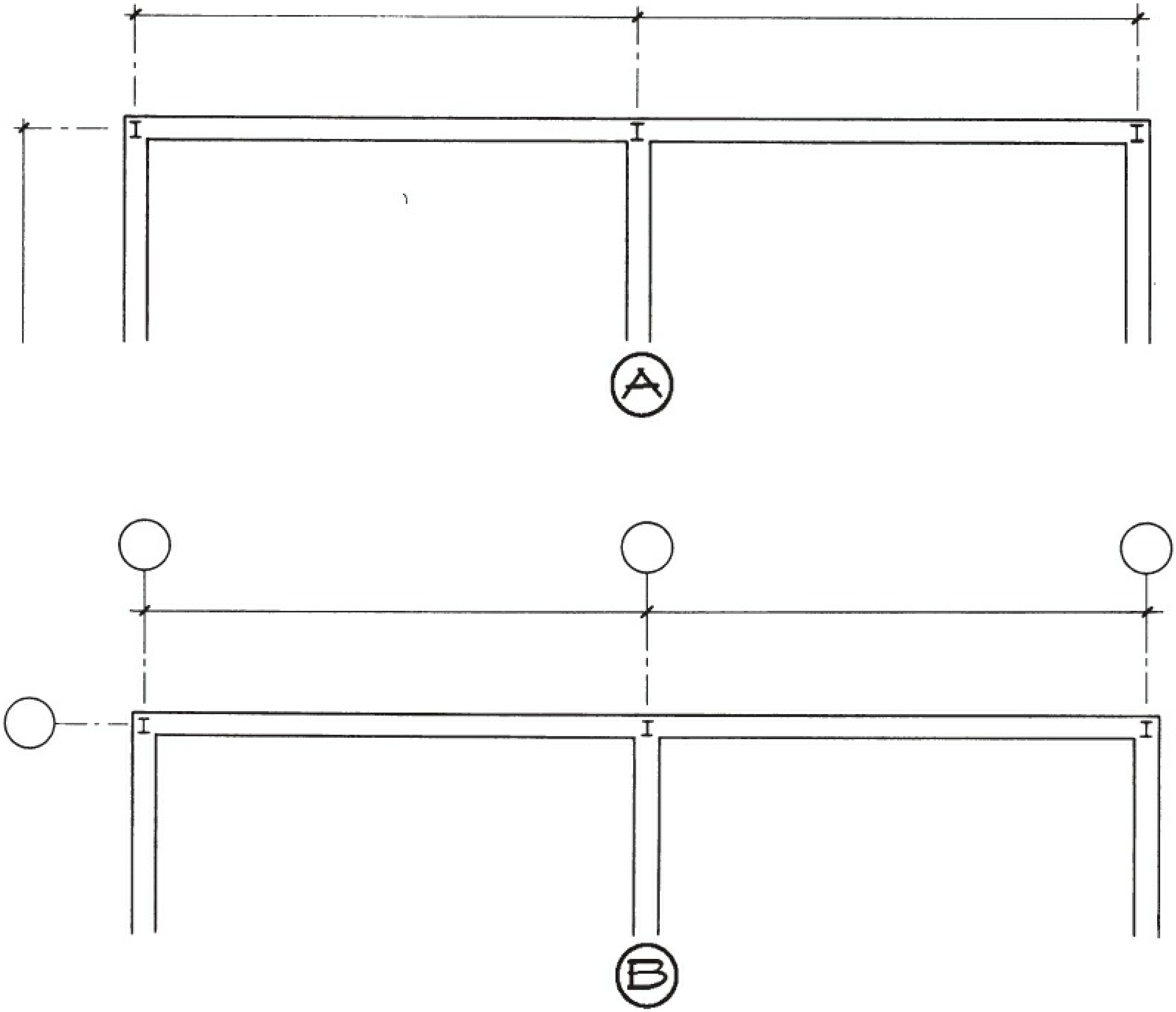


Figure 8.35 Dimensioning a floor plan with steel columns.

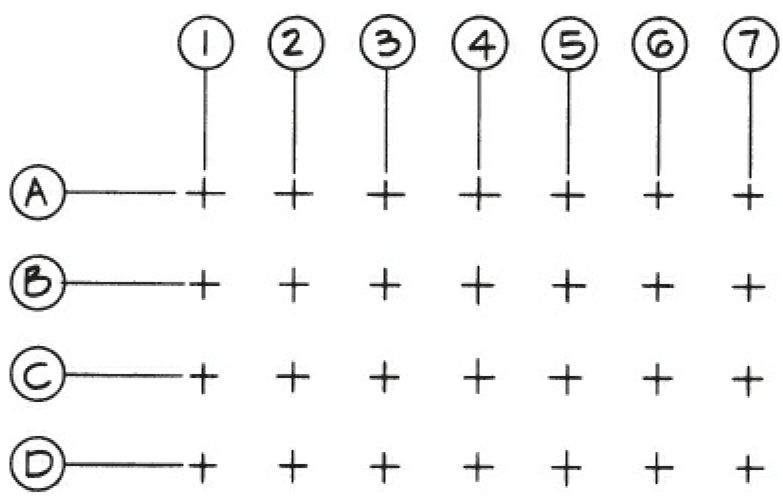


Figure 8.36 Columns forming a grid pattern.

Dimensioning Walls. Walls, especially interior walls that do not fall on the established grid, have to be dimensioned—but only to the nearest dimension grid line. Figure 8.37 is a good example of an interior wall dimensioned to the nearest column falling on a grid.

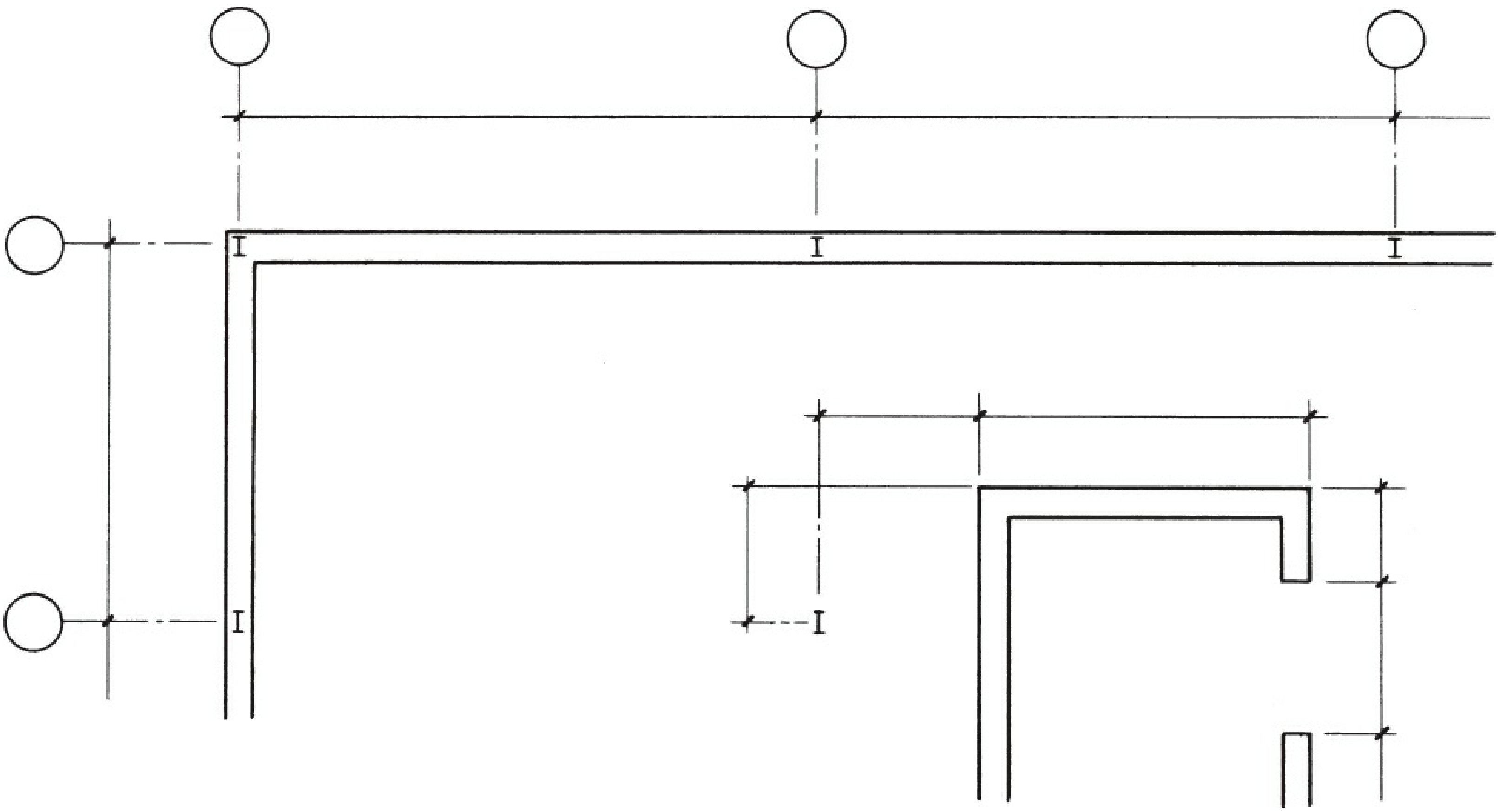


Figure 8.37 Locating interior walls from axial reference bubbles.

Combinations of Materials

Because of design or code requirements for fire regulations or structural reasons, materials are often combined: concrete columns with wood walls; steel mainframe with wood walls as secondary members; masonry and wood; steel studs and wood; and steel and masonry, for example. Figure 8.38 shows how using two different systems requires overlapping dimension lines with extension lines. Because dimension lines are more critical than extension lines, extension lines are *always* broken in favor of dimension lines. The wood structure is located to the column on the left side once and thereafter dimensioned independently.

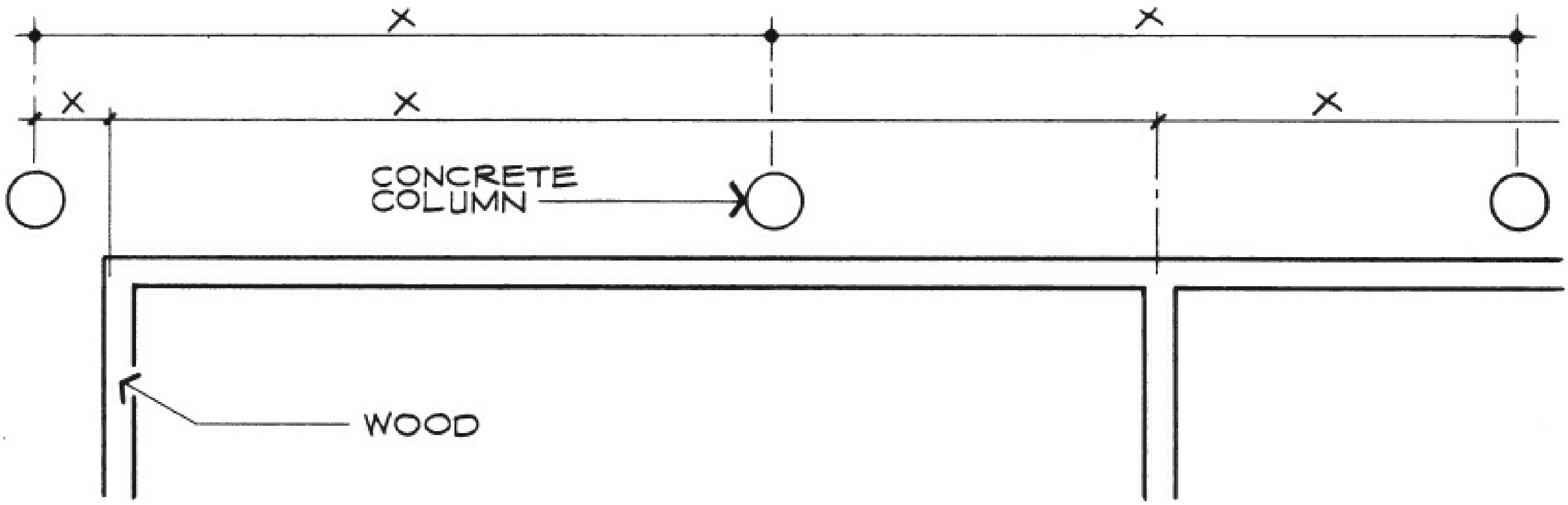


Figure 8.38 Concrete and wood.

Wood and Masonry. Wood and masonry, as shown in Figure 8.39, are dimensioned as their material dictates: the masonry is dimensioned to the ends of the wall and the rough opening of windows, while the wood portions are dimensioned to the center of interior walls, center of doors, and so forth. The door in the wood portion is dimensioned to the center of the door and to the inside edge of the masonry wall. This assumes that the block wall will be built first.

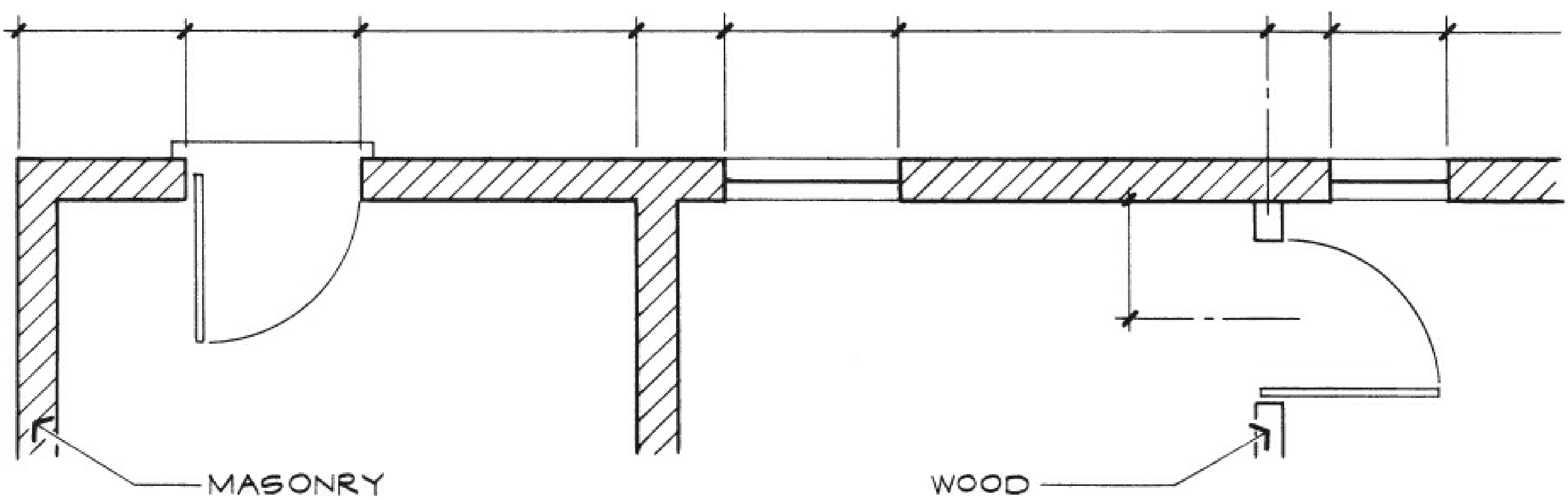


Figure 8.39 Wood and masonry.

Masonry and Concrete. Masonry walls and concrete columns, shown in Figure 8.40, are treated in much the same way as wood and concrete columns. In both instances, the building sequence dictates which one becomes the reference point (datum). See Figure 8.41. Here, steel and masonry are used in combination. Using the dimensional reference system, the steel is installed first. The interior masonry wall is then located from the nearest axial reference plane, and dimensioned according to the block module for that kind of masonry. Additional axial reference plane sub…bubbles are provided. Numbers are in decimals. Because one face of the masonry wall is between 1 and 2, 7/10 of the distance away from axial reference plane 1, the number 1.7 is used in the sub…bubble. Also, because the same wall is also halfway between A and B, A.5 is used as a designation. Another example of the process is found in Figure 8.42. The fabricators will locate the

steel first, then the masonry wall. Dimension “X” relates one system to another.

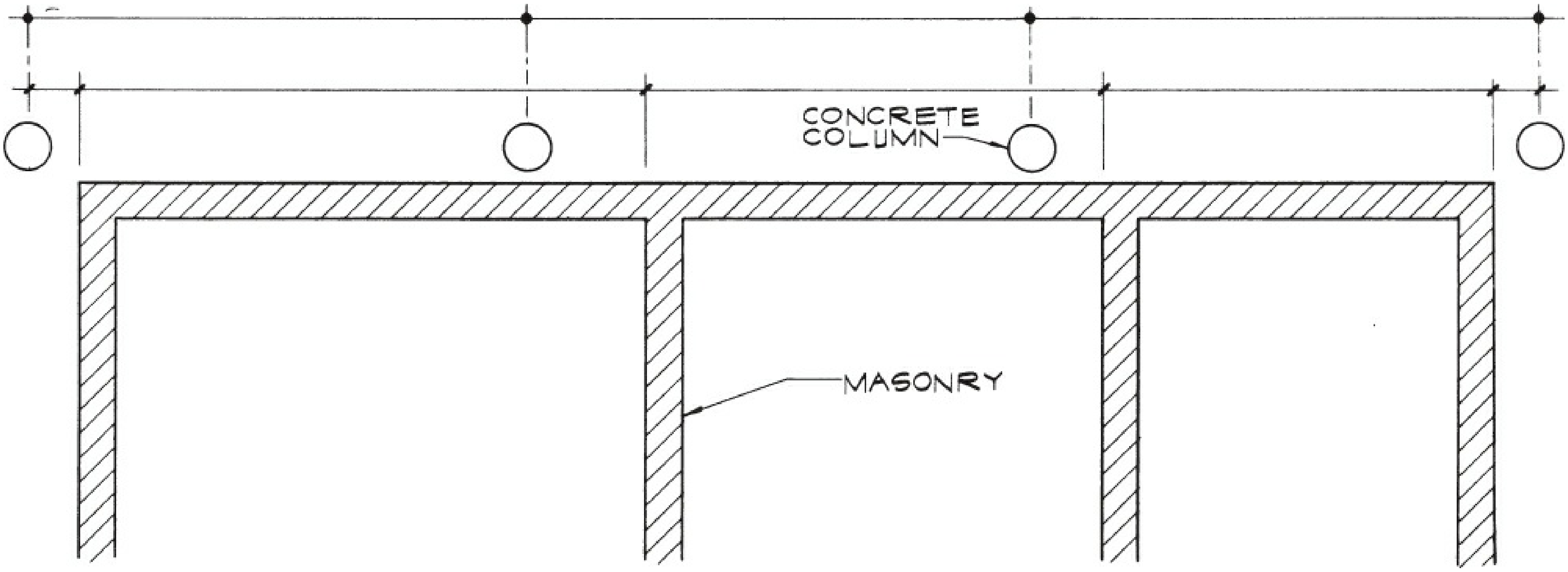


Figure 8.40 Concrete columns and masonry walls.

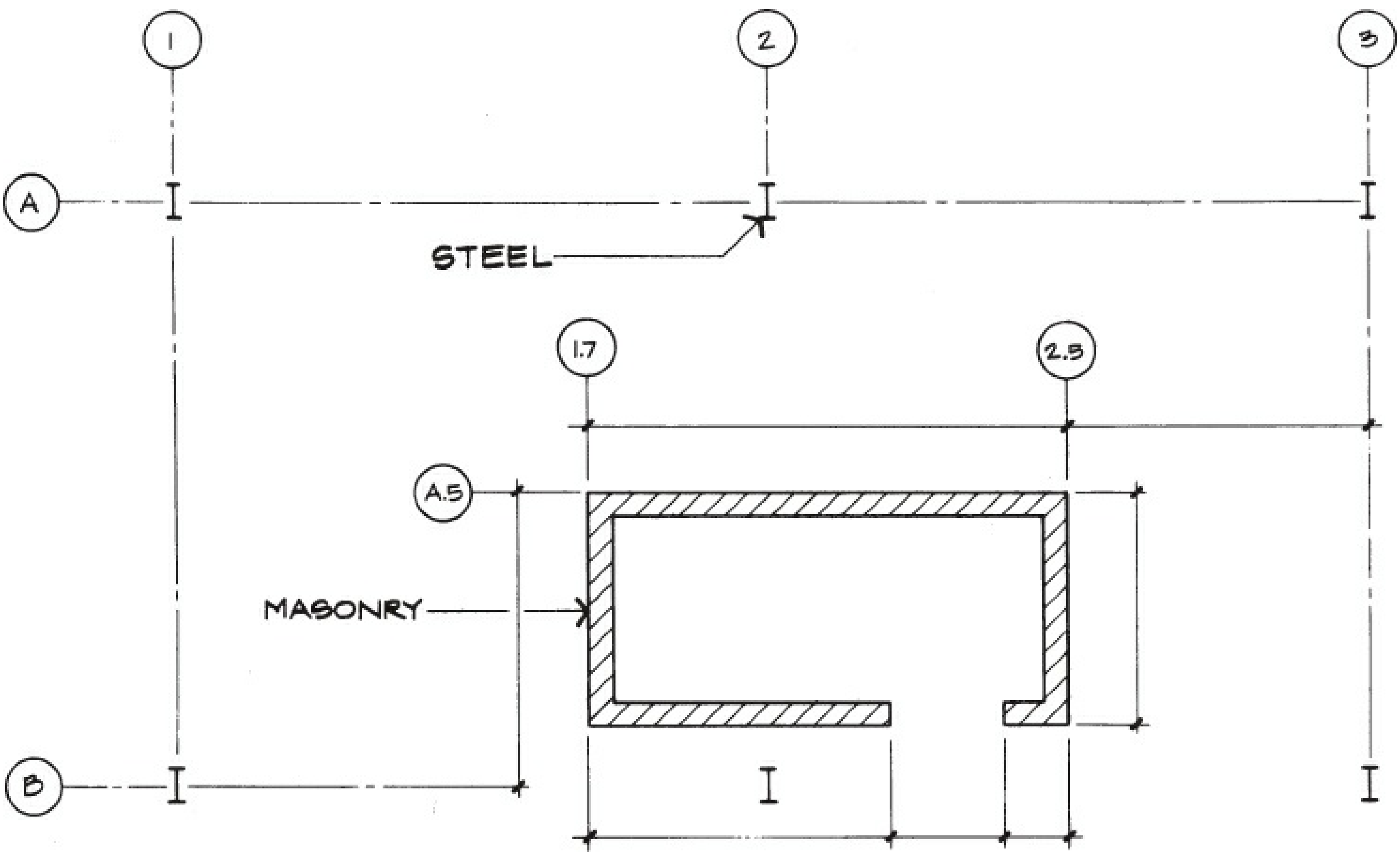


Figure 8.41 Steel and masonry.

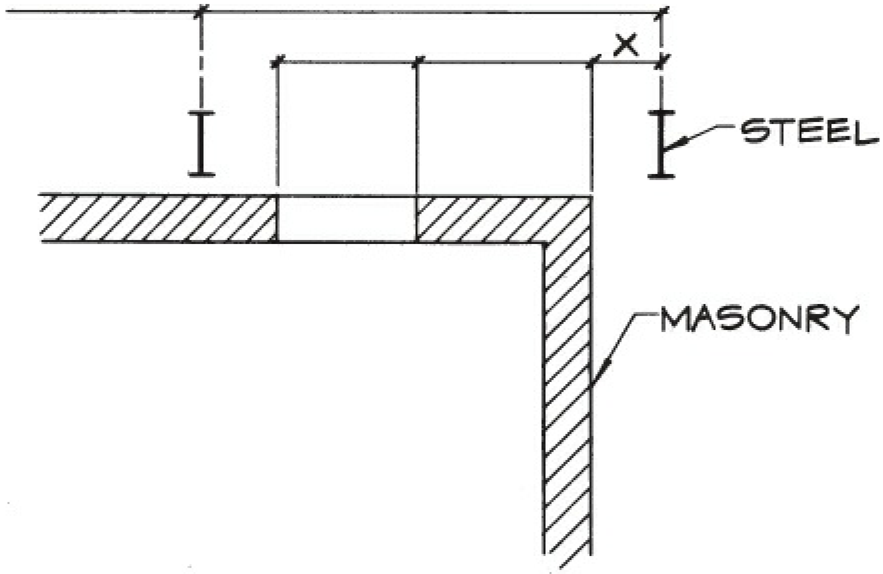


Figure 8.42 Steel and masonry.

Doors in Plan View

The general method of dimensioning a window or a door was discussed earlier. Here, we examine a variety of doors and windows and how to draft them. Figure 8.43 shows a sampling of the most typically drafted doors.

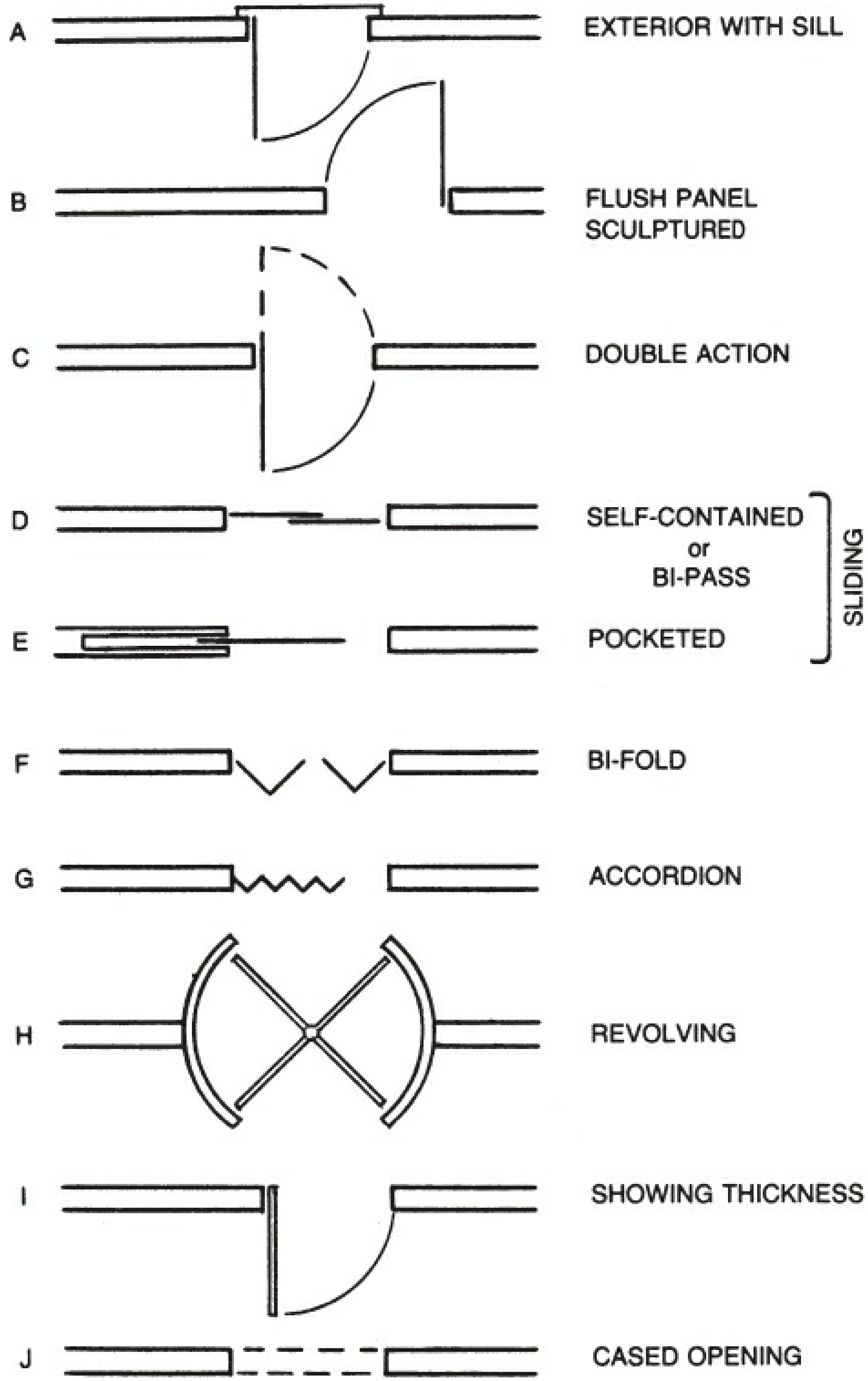


Figure 8.43 Doors in plan view.

Hinged. Doors A and B in Figure 8.43 show the main difference in drafting an **exterior hinged door** versus an **interior hinged door**. A straight line is used to represent the door, and a radial line is used to show the direction of swing. Door "I" shows the same kind of door with its thickness represented by a double line. Doors A, B, and I are used in the floor plans to show flush doors, panel doors, and sculptured doors (decorative and carved).

Flush. Flush doors, as the name indicates, are flush on both sides. They can be solid on the interior (solid slab) or hollow on the inside (hollow core).

Panel. Panel doors have panels set into the frame. These are usually made of thin panels of wood or glass. A variety of patterns are available. See *Sweet's Catalog File* under "Doors" for pictures of door patterns. Also see the earlier discussion of elevations for a drafted form of these doors.

Sculptured and Decorative. Sculptured and decorative doors can be carved forms put into the doors in the form of a panel door, or added onto a flush door in the form of what is called a **planted** door. Different types of trim can also be planted onto a slab door.

Double Action. Door C in Figure 8.43 represents a double…action door, a door that swings in both directions. Double…action doors can be solid slab, panel, or sculptured.

Sliding. Two types of sliding doors are shown in Figure 8.43. Door D, when used on the exterior, typically is made of glass framed in wood or metal. Pocketed sliding doors are rarely found on the exterior because the pocket is hard to weatherproof, and it is difficult to keep rain, termites, and wind out of the pocket.

Folding. Doors F and G are good doors for storage areas and wardrobe closets.

Revolving. Where there is a concern about heat loss or heat gain, a revolving door is a good solution. See door H, which shows a cased opening, that is, an opening with trim around the perimeter with no door on it.

Windows in Plan View

Typical ways of showing windows in the plan view are shown in Figure 8.44. When a plan is drawn at a small scale, each individual window, of whatever type, may simply be drawn as a fixed window (window A, Figure 8.44), depending for explanation on a pictorial drawing (as shown in Chapter 2). Ideally, casement, hopper, and awning…type windows should be used only on the second floor or above, for the sake of safety. If they are used on the first or ground floor, they should have planters or reflection pools or something else around them to prevent accidents.

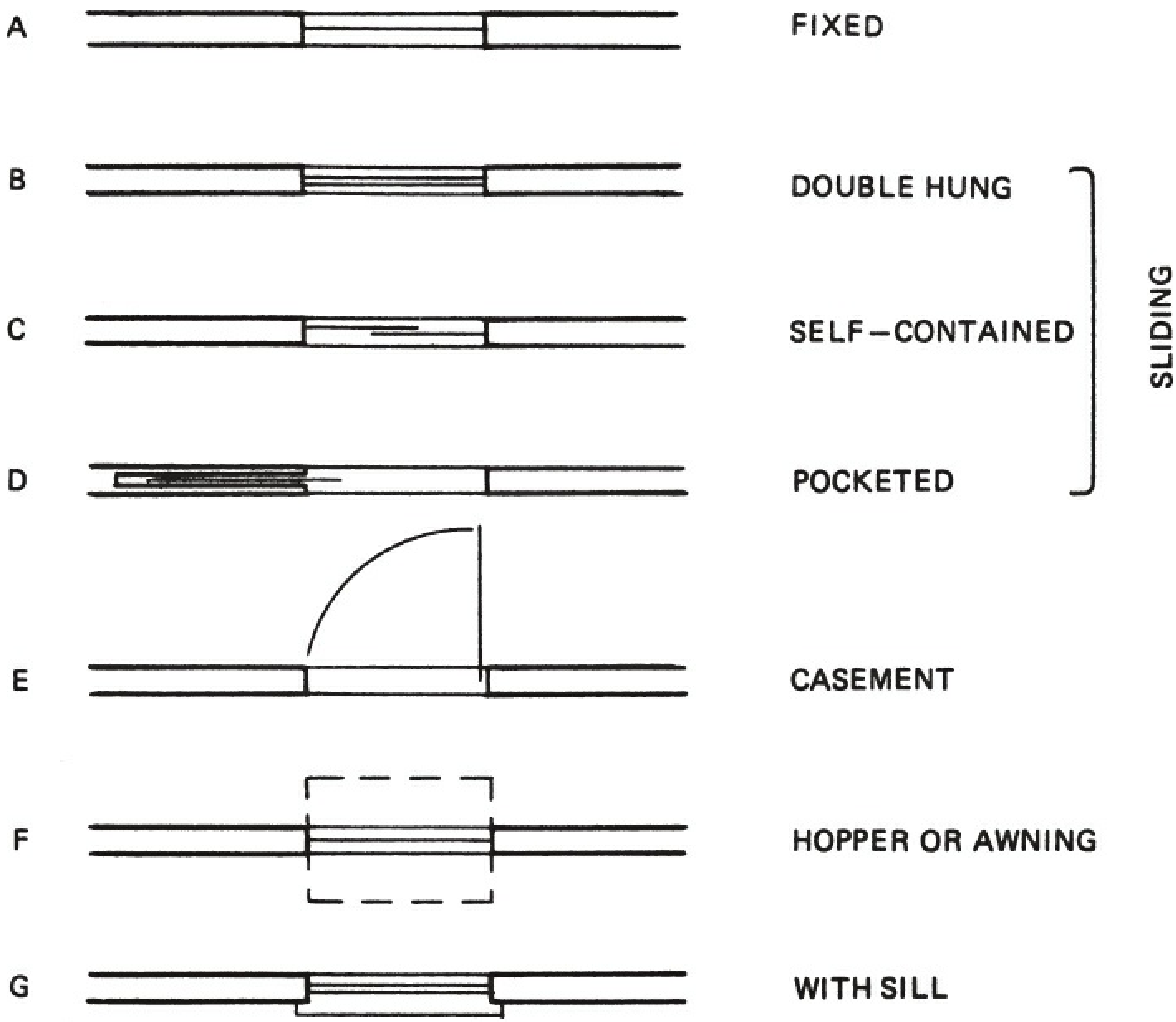


Figure 8.44 Windows in plan view.

Sizes of Doors and Windows

The best way to find specific sizes of windows and doors (especially sliding glass doors) is to check *Sweet's Catalog File*. There, you will find interior doors ranging from 1′…6″ to 3′…0″ and exterior doors ranging from 2′…4″ to 3′…6″. Sizes of doors and windows also depend on local codes. Local codes require a certain percentage of the square footage to be devoted to windows and doors to provide light and ventilation. These percentages often come in the form of minimum and maximum areas as a measure of energy…efficient structures. Still another criterion for door size is consideration of wheelchairs and the size required for building accessibility (Americans with Disabilities Act compliance).

SYMBOLS

Electrical and Utility Symbols

Just as chemistry uses symbols to represent elements, architectural floor plans use symbols to represent electrical and plumbing equipment. Figure 8.45 shows the ones most typically used. These are symbols only. They do not represent the shape or size of the actual item. For example, the symbol for a ceiling outlet indicates the *location* of an outlet, not the shape or size of the fixture. The description of the specific fixture is given in the specifications document.

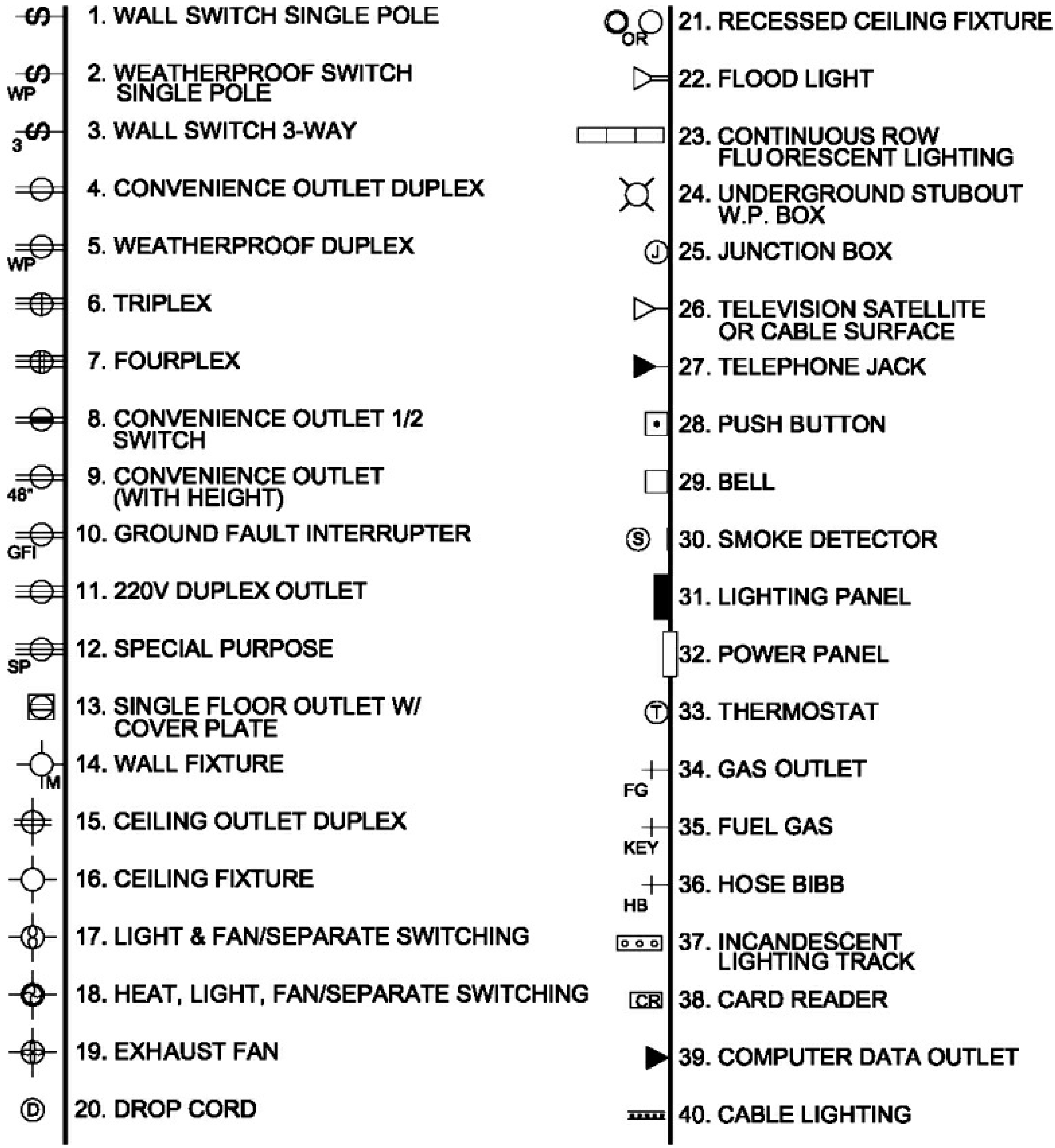


Figure 8.45 Electrical and utility symbols.

Some symbols are more generally used than others in the architectural industry. A floor plan, therefore, usually contains a legend or chart of the symbols being used on that particular floor plan.

Number Symbols

Symbols 1, 2, and 3 in Figure 8.45 show different types of switches. Symbol 2 shows a weatherproof switch, and symbol 3 shows a situation in which there might be a number of switches used to turn on a single light fixture or a series of light fixtures. See Figure 8.46. A centerline…type line is used to show which switch connects with which outlet. This is simply a way of giving this information to the electrical contractor. (However, Figure 8.46 is not a wiring diagram.) If one switch controls one or a series of outlets, it is called a two…way switch. A three…way switch comprises two switches controlling one outlet or a series of outlets. Three switches are called a four…way, and so on. Thus, you name switches by the number of switches plus one. For example, the number 3 is placed next to the switch when there are two switches, the number 4 for three switches, and so on. See Figure 8.46 for examples of switches, outlets, and their numbering system.

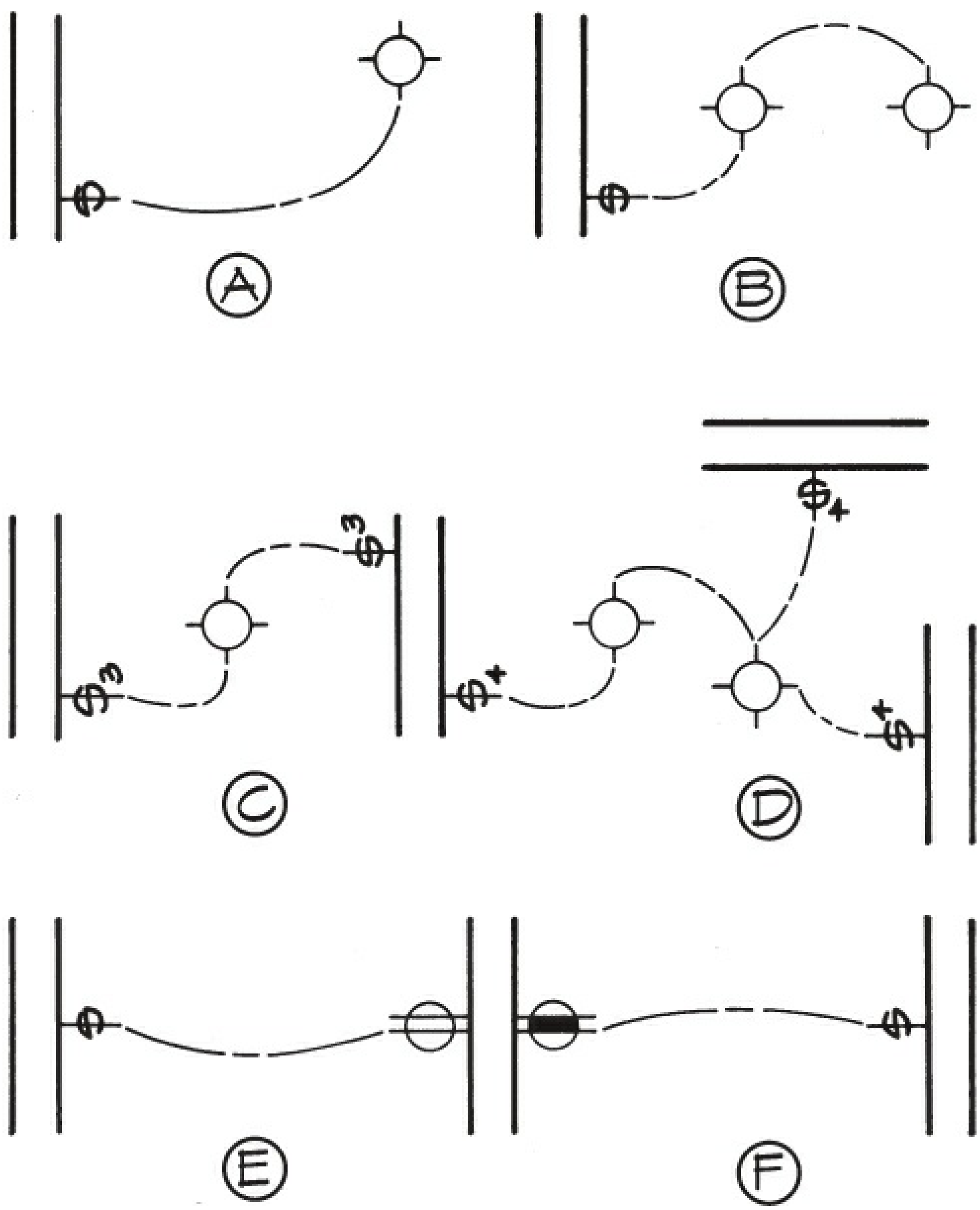


Figure 8.46 Switch to outlet (conventional).

Symbol 4 in Figure 8.45 represents a duplex convenience outlet with two places to plug in electrical appliances.

Numbers are used to indicate the number of outlets available other than the duplex, the most typical. For example, if a triplex outlet is required, the number 3 is placed beside the outlet symbol. A number in inches, such as 48″, may be used to indicate the height of the outlet from the floor to the center of the outlet. See Figure 8.45, symbols 6, 7, and 9.

Letter Symbols

A letter used instead of a number represents a special type of switch. For example, “K” is used for key…operated, “D” for dimmer, “WP” for weatherproof, and so forth.

As with switches, letter designations are used to describe special duplex convenience outlets, for example, “WP” for waterproof. A duplex convenience outlet is generally referred to by the public as a wall plug.

The call letters “GFI” mean ground fault interrupt. They designate a special outlet used near water (bathrooms, kitchens, etc.) to prevent electric shock. “SP” designates special purpose—perhaps a computer outlet on its own circuit and unaffected by electrical current flowing to any other outlet.

A combination of a switch and a regular outlet is shown in Figure 8.45, symbol 8. This illustration shows a duplex convenience outlet that is half active (hot) at all times. In other words, one outlet is controlled by a switch and the other is a normal outlet. The switch half can be used for a lamp, and the normal outlet for an appliance.

Other Symbols

A square with a circle within it and two lines represents a floor outlet. See symbol 13, Figure 8.45. The various types of light outlets are shown by symbols 14 through 18.

A **flush outlet** is one in which the fixture will be installed flush with the ceiling. The electrician and carpenter must address the problem of framing for the fixture in the members above the ceiling surface. See symbol 21, Figure 8.45.

A selection of miscellaneous equipment is shown in symbols 22 through 36.

Special Explanation

Symbols 24, 25, 26, 28, 31, and 32 in Figure 8.45 require special explanation:

Symbol 24. Used for electrical connections (usually on the outside) for such things as outdoor lighting and sprinkler connections.

Symbol 25. A “J” box is an open electrical box that allows the electrician to install fixtures or tie wires together at that location.

Symbol 26. This is not the TV antenna itself, but the point at which you connect a television antenna line from cable or satellite dish.

Symbol 28. Location to push a button to ring a doorbell or chime.

Symbol 31. The connection between the utility company and the structure where the power panel is installed.

Symbol 32. As the structure is zoned for electrical distribution, circuit breaker panels are installed. This allows you to reset a circuit at a so…called substation without going outside to the main panel or disturbing the rest of the structure.

Symbol 34 represents a gas outlet, and 35 a control for fuel gas. Symbol 34 would be used to indicate a gas jet in a fireplace, and 35 would be used to indicate the control for the gas, probably somewhere near the fireplace. Symbol 36 is a hose bibb, a connection for a water hose.

Symbols 37 through 39 represent present…day symbols. Incandescent track lighting is shown in 37; 38 indicates a card reader for a security door, such as a hotel room door or conference room door, that is opened by a card reader. Symbol 39 represents an outlet through which to receive computer data. Symbol 40 indicates two wires mounted on the ceiling for attachment of the movable and repositionable light often referred to as *cable lighting*.

Electrical and Computers

Although most residences are still wired in the conventional manner, use of the computer to control circuitry has found its way into the architectural construction world. Today, we are being asked to think in terms of the following:

1. What type of general lighting would be appropriate for a given structure?
2. What wall washes, by color and intensity, should be used in a specific area?
3. What specific tasks are to take place in an area, and what kind of lighting would satisfy the requirements of this task?
4. What type of mood do we wish to create, and how will we dim or employ colored lights to produce that specific mood?
5. How should the floor area be lit to facilitate the safe movement of people through a corridor at night or during the day, as in a school environment?
6. How can we efficiently light stairs, both to identify the positions of the steps and to show where they begin?
7. How will specialty lighting be employed, such as fiber optics or neon lighting to identify an entry area or light located to produce a light beacon to the sky at night?

Electrical wiring falls into three basic categories: conventional, retrofit, and centralized controller (computer).

1. *Conventional*. This system presently exists in the majority of today's structures. Lights are hardwired from switch to outlet, and the system is not very flexible (see Figure 8.46).
2. *Retrofit:*
   a. *Radio frequency*. An old conventional toggle…style switch is replaced by what we will refer to as a “smart switch.” The smart switch is capable of transmitting and receiving signals to and from other outlets (modules). This system is ideal in building additions and alterations where the cost of rewiring can become prohibitive. Radio…wave signals can be disturbed by steel studs, the chicken wire present in older walls as a base mesh for stucco or plastic, or by distance (approximately 25′ distance limit).
   b. *Power line carrier (PLC)*. Also uses smart switches, but rather than sending a radio…wave signal, it sends an electrical pulse through the existing wiring. A single switch can be replaced with a smart switch with multiple controls. This enables one smart…switch location to control multiple outlets, fixtures, appliances, and so forth. HomeTouch by Lite…Touch, Inc. is an example of such a system.
3. *Centralized controller (computer)*. Using low…voltage wires, the switches are connected to a central processor. We no longer think in terms of a single light switch controlling a bank of lights, but rather a single control station with as many as nine buttons that can control any or all lights in a structure. These *control stations*, which are wall…mounted keypads, replace the old…fashioned switches and dimmers (see Figure 8.47B). Note that nine switches and dimmers are replaced with one control station the size of a single…gang toggle switch.

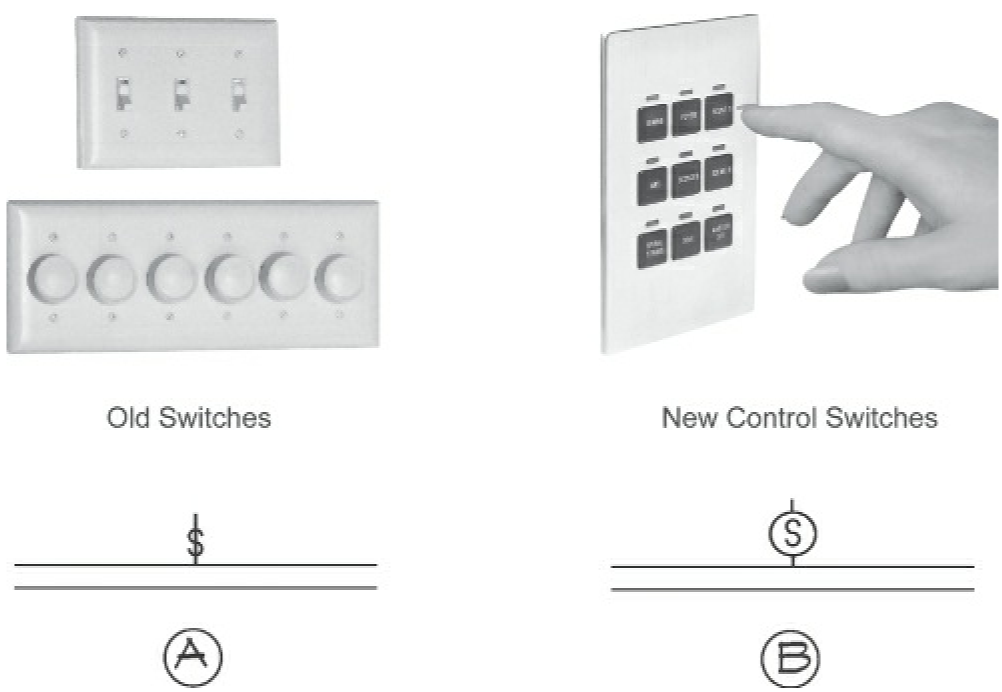


Figure 8.47 Change from old to new smart switches (called *control stations*).

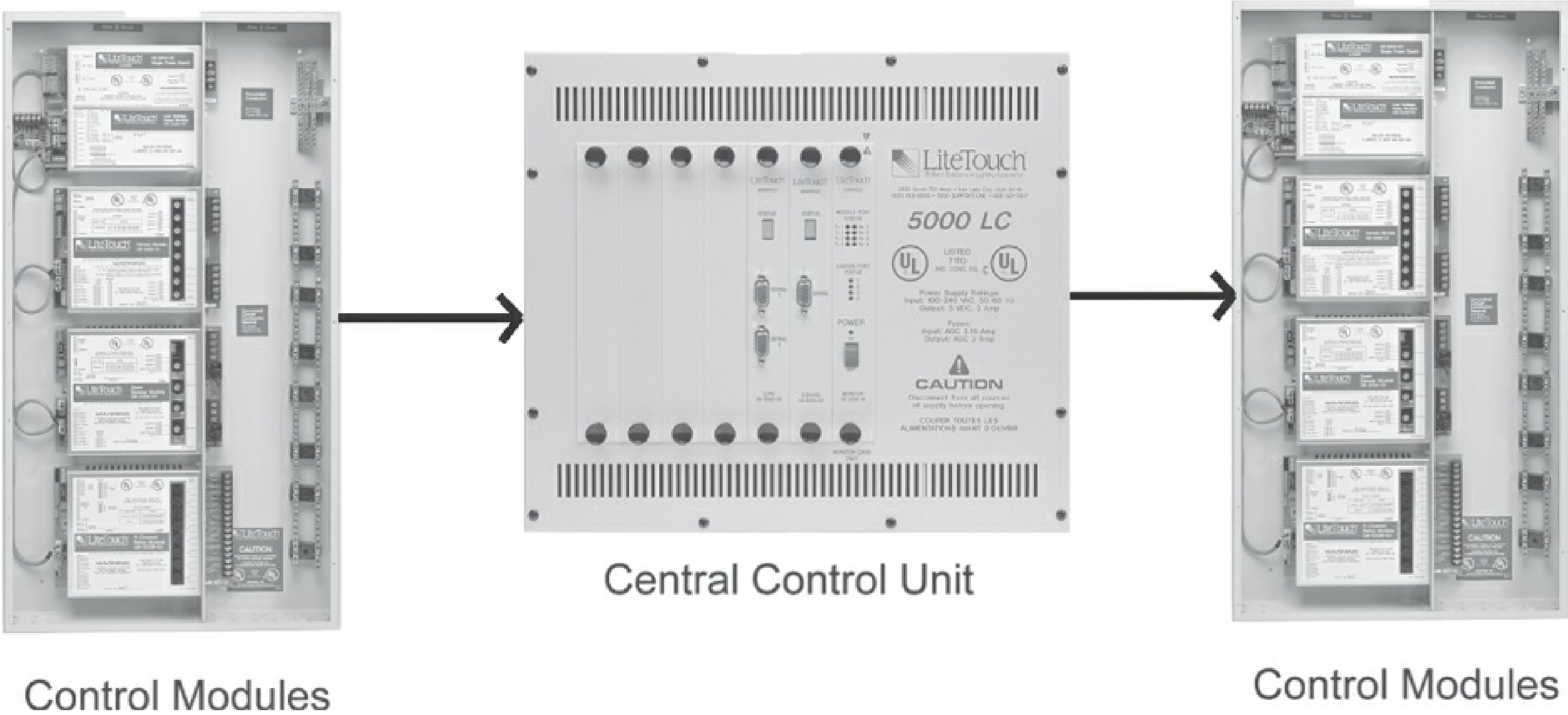
Figure 8.47A is a conventional switch similar to that shown in Figure 8.45. With a simple circle added to an existing switch, a drafter can indicate that a smart switch should be

installed. Thus, you can easily adjust an existing drawing. Figure 8.47B shows a slight variation of the same smart switch that is drafted from scratch.

The first major change is in the way we think about lighting. Do not think of a room with its lighting controlled by a single switch; instead, plan lighting scenes. Position the lighting to create a visual pathway through a structure. Consider how you would light the exterior of the structure for visual impact or to deter possible intruders (possibly motion…activated flashing lights). Think in terms of how best to secure your house electrically, by opening or closing windows or draperies. Controls can also be programmed to provide music throughout a structure, to activate a television, or even to dramatically showcase works of art.

The next step to take with your client is to decide from which locations you would like to control these various lighting scenes. Let us now look at the three basic components in this type of control system. As mentioned before, the first are the control stations, wall…mounted keypads suitable for use in both wet and dry areas of a structure. The second is the central control unit (CCU). The CCU is the brain of the system, that is, where the programming resides. It receives signals from the control stations and then processes them. Each control station is connected to the CCU with low…voltage wire. This is very different from the old system, in which the lights were hooked up to the control station. Once programmed, the CCU will maintain the information even during a power outage or spike—and, yes, the CCU can be programmed for times when the occupants are away on vacation. Lighting can be programmed to give the structure an appearance of being occupied and then returned to its original setting upon the owners' return. The client can be trained to program his or her own system, or the system installer can reprogram the system via the telephone. Thus, a technician need not come to the structure to reprogram the CCU.

Control modules make up the third component. These are self…contained modules that actually do the work. Receiving their instructions from the CCU, they dim lights; drive motorized devices to open skylights, windows, and draperies; raise or lower the screen in a home theater; or merely turn on the garden and pool lights (see Figure 8.48).



[**Figure 8.48**]() Three components of the Lite…Touch system.

Drawing for the Installer

The next task is to convey to the installer the information about the system you have designed, the location of the control stations, and the number of control points you have at one location. The number of control points at a given location can be dealt with using a chart. A **routing schedule** (a chart similar to that shown in [Figure 8.49]()) can easily be developed and become part of the electrical plan. The first column identifies the location of the control station in the structure, and the second column actually tells the manufacturer the actual number of control points needed. Each control station in that location (say #1) is then labeled, such as 1A, 1B, 1C, 1D, and so on.

Routing Schedule								
	Number of Housed	Individual	Connected to System	Number of Outlets	Dimmer % (100% is Full)	Location	Type	Remarks
1	6	1A	E-1	4	100	LIVING	GENERAL	-
		1B	E-2	6	60	LIVING	SPOT	-
		1C	E-3	2	40	LIVING	MOOD	-
		1D	C	1	100	OUTSIDE	SECURITY	-
		1E	M	2	40	HALL	PATH	-
		1F	L	2	80	DINING	GENERAL	-
2	4	2A	E-1	2	100	DINING	GENERAL	
		2B	F-2	2	80	DINING	GENERAL	
		2C	L	4	80	OFFICE	SPOT	

Figure 8.49 Routing schedule.

Each group of outlets—for example, six outlets in the ceiling in the living room—is then given a call letter. In this chart, the designation E…1 is used for the general light in the living room, E…3 is used for mood lighting, and E…2 may be used as a spotlight for paintings.

Control…station groups can be identified with a single number (see Figure 8.50A). The symbol should be a square. The outlets are connected as in the conventional method but are not connected to the control stations identified by a C and an S with a line through it. Now look at Figure 8.50B. The outlets are connected to a symbol that should be a square. The symbol should not duplicate those already used for the control stations.

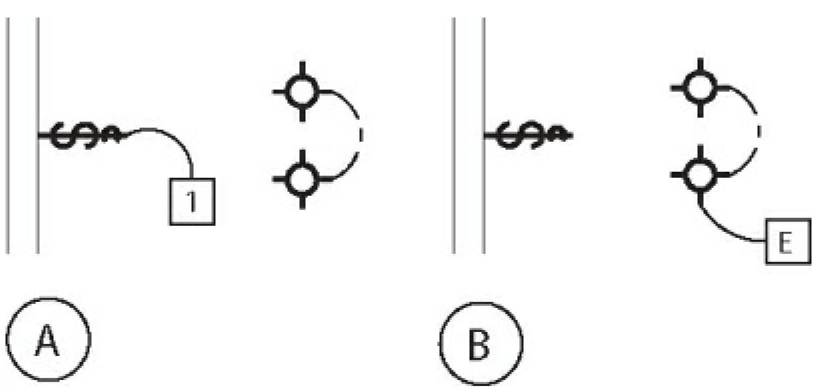


Figure 8.50 Routing symbol for control stations/outlets.

The electrical symbols shown in this chapter are mostly used in residential applications, although most of them are similar in commercial, institutional, and industrial settings. For hospitals, you need a symbol for a nurse call system or signal center system and very

specialized auxiliary systems. You may also need to run a multitude of equipment for surgery at one time, and provide a system that cannot be compromised during surgery. In an office or school building, you may need an electrical door opener or interconnecting telephone service and in…floor ductwork for a computer room.

Appliance and Plumbing Fixture Symbols

Many templates are available for drafting plumbing fixture and kitchen appliances. A good architectural template contains such items as:

- Circles
- Various kitchen appliances
- Door swings
- Various plumbing fixtures
- Electrical symbols
- Typical heights marked along edges

Figure 8.51 shows some of these fixtures and appliances.

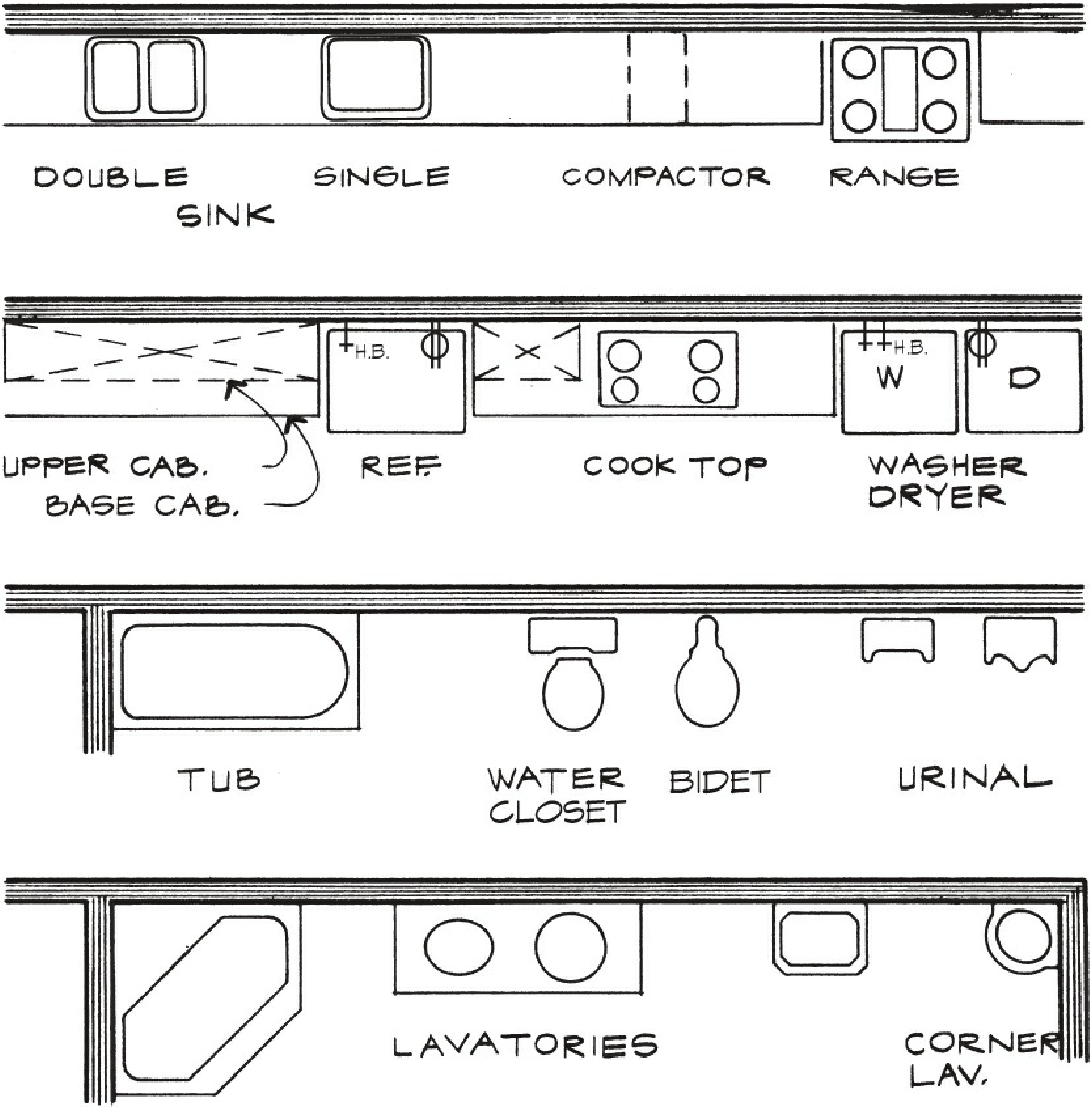


Figure 8.51 Appliance and plumbing fixtures.

OTHER FLOOR…PLAN CONSIDERATIONS

It is often necessary to show more than one or two building materials on a floor plan. Let us take a college music building as an example of a structure that has a multitude of walls of different materials, including:

1. Masonry

2. Wood studs
3. Two types of soundproof partitions
4. Low walls
5. Low walls with glass above

We need to establish an acceptable symbol for each material and to produce a legend similar to that in Figure 8.52. A sample of a partial floor plan using some of these materials symbols is shown in Figure 8.53.

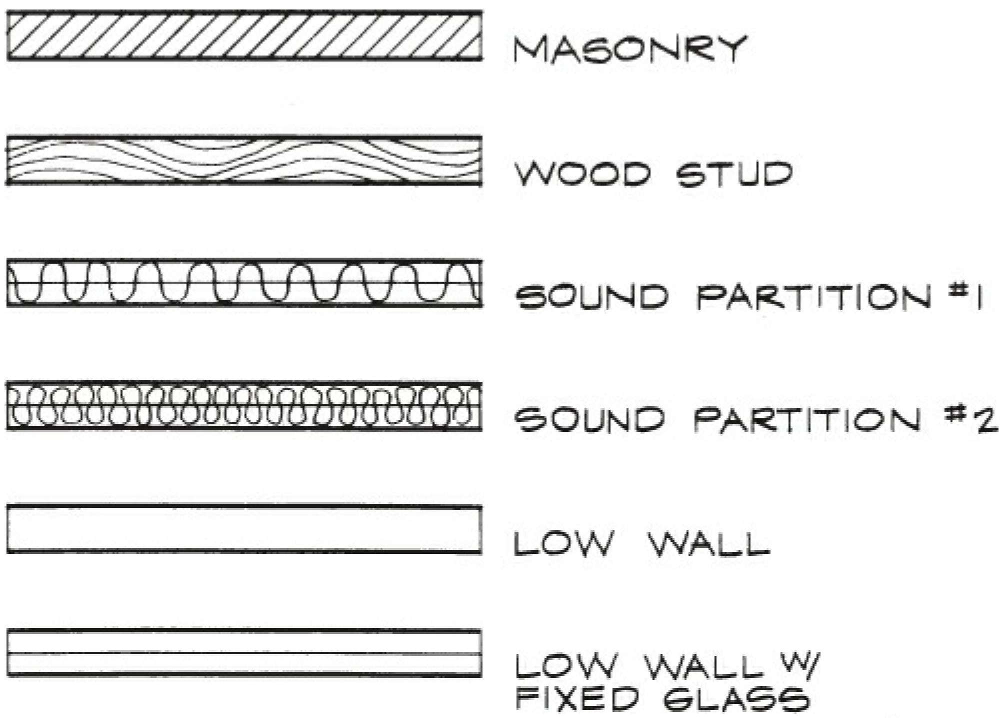


Figure 8.52 Legend for music building floor plan.

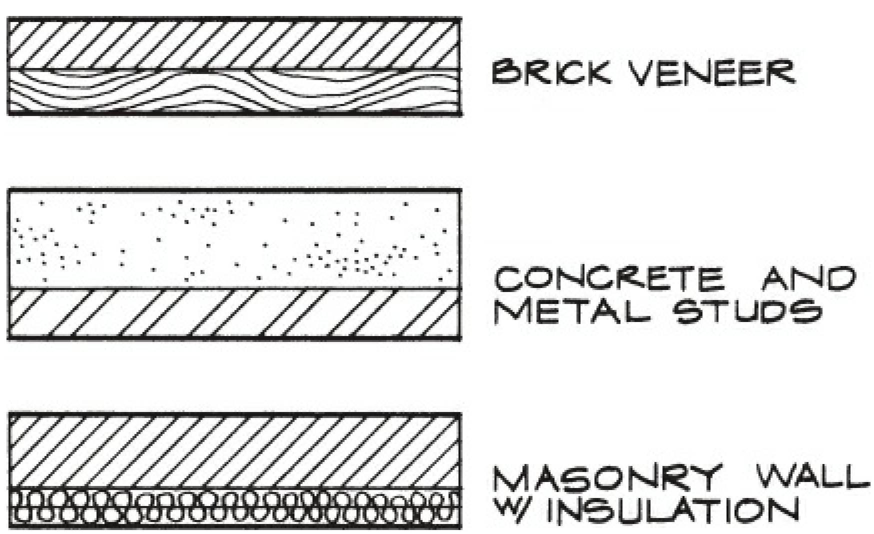


Figure 8.53 Partial floor plan: Music building.

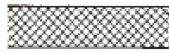
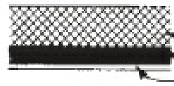
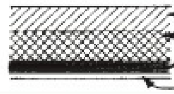
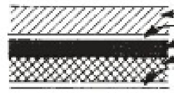
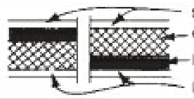
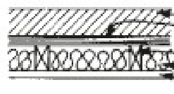
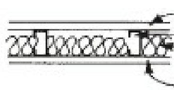
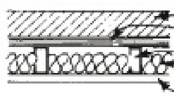
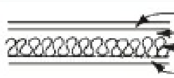
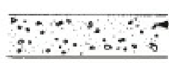
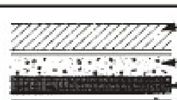
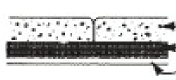
Combining Building Materials

Because of ecological requirements (such as insulation), structural reasons, aesthetic concerns, and fire regulations, materials often must be combined. For example, insulation

may be adjacent to a masonry wall, a brick veneer may be on a wood stud wall, and steel studs may be next to a concrete block wall. Figure 8.54 shows examples of what some of these combined…materials walls will look like on the floor plan.

EXTERIOR WALL ASSEMBLIES

FOR ADDITIONAL INFORMATION CONSULT MANUFACTURERS LITERATURE AND TRADE ASSOCIATIONS

		WALL THICKNESS (NOMINAL) (IN.)
C. M. U.	 C. M. U. (GRAVEL AGGREGATE)	8 12
C. M. U. (INSULATED)	 C. M. U. INSULATION INT. WALL FIN.	8 + 12 +
C. M. U. AND BRICK VENEER (INSULATED)	 BRICK VENEER C. M. U. INSULATION INT. WALL FIN.	4 + 4 + 4 + 8 +
CAVITY	 BRICK VENEER CAVITY (MIN. 2") INSULATION (WATER REPELLENT) C. M. U. INT. WALL FIN.	4 + 2 + 4 4 + 2 + 8
C. M. U. AND STUCCO (INSULATED)	 STUCCO C. M. U. INSULATION INT. WALL FIN.	8 +
WOOD STUD	 EXT. WALL FIN. SHEATHING WITH MOISTURE BARRIER WOOD STUD INSULATION WITH VAPOR BARRIER INT. WALL FIN	4 6
BRICK VENEER	 BRICK VENEER SHEATHING WITH MOISTURE BARRIER WOOD STUD INSULATION WITH VAPOR BARRIER INT. WALL FIN.	4 + 4
METAL STUD	 EXT. WALL FIN. METAL STUD AT 16" O.C. INSULATION WITH VAPOR BARRIER INT. WALL FIN.	4 5
BRICK VENEER	 BRICK VENEER SHEATHING WITH MOISTURE BARRIER METAL STUD AT 16" O.C. INSULATION WITH VAPOR BARRIER INT. WALL FIN.	4 + 4
INSULATED SANDWICH PANEL	 METAL SKIN AIRSPACE INSULATING CORE METAL SKIN	5
CONCRETE	 CONCRETE	8 12
CONCRETE (INSULATED)	 CONCRETE INSULATION INT. WALL FIN.	8 +
CONCRETE AND BRICK VENEER (INSULATED)	 BRICK VENEER CONCRETE INSULATION INT. WALL FIN.	4 + 8 +
PRECAST CONCRETE	 CONCRETE (REINFORCED) INSULATION INT. WALL FINISH	2 + 4 +
PRECAST CONCRETE SANDWICH	 CONCRETE INSULATION	5

GLASS SEE INDEX UNDER "GLASS"

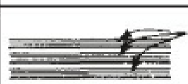
SINGLE GLAZING	 1/4" GLASS	1/4
DOUBLE GLAZING	 1/4" GLASS 1/4" CAVITY	3/4
TRIPLE GLAZING	 1/4" GLASS 1/4" CAVITY	1 1/4

Figure 8.54 Combinations of building materials.

Repetitive Plans and Symmetrical Items

If a plan or portions of a plan are symmetrical, a centerline can be used and half of the object dimensioned. If a plan is repetitive—for example, an office building or an apartment or condominium—each unit is given a letter designation (Unit A, Unit B, etc.). These are then referenced to each other and only one is dimensioned.

For example, suppose you are drafting a floor plan for an eight…unit apartment structure; these eight units are to be divided into four one…bedroom units and four two…bedroom units, all using the same basic plans. Your approach could be to draft the overall shape of the structure, and then draft the interior walls only on one typical unit and label it completely. The remaining units (three of each) are referenced to the original unit by a note such as “See Unit A for dimensions and notes.”

The whole plan is made by putting the fully drafted plans in the proper position to produce the overall shape.

Dimensional Reference Numbers and Letters

The dimensional reference system was discussed earlier (see Chapter 3). Responsibility for placement of the letters and numbers, and often the drafting of the dimensional reference bubbles, rests with the structural engineer. Because the structural engineer is responsible for sizing and locating the columns for proper distribution of the building weight, only the structural engineer can make the proper choices. This information can then be taken and put in the reference bubbles on the foundation plan, building section, framing plans, and so forth.

Poché Walls

The word **poché**, mentioned earlier, refers to the process of darkening the space between the lines that represent wall thickness on a floor plan. A special pochéd wall can easily be done on the computer with lines or dots. However, each line type must mean something. It might mean an existing wall, or a wall to be, or even a new wall. Figure 8.54 shows an example of pochéd walls.

Stairs

An arrow is used on the plan of the stair to show the direction in which the stair rises. See the partial floor plan in Figure 8.55. Notice how the arrowheads show direction and how the number and size of the treads and risers are indicated.

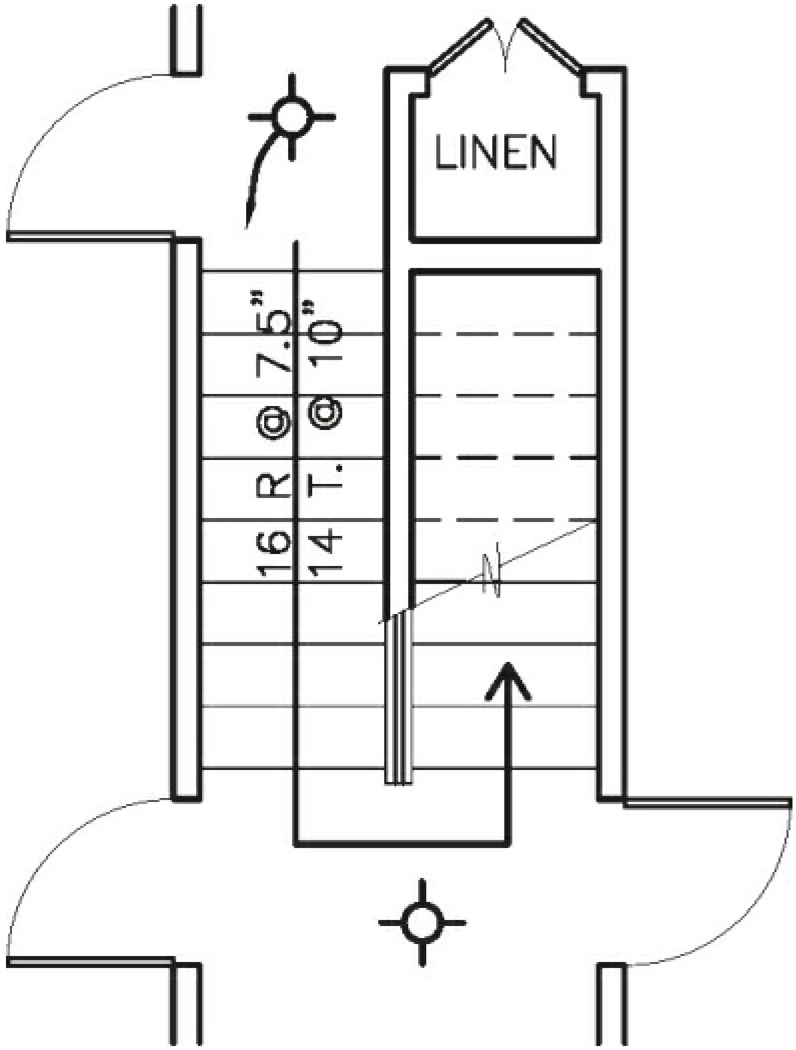


Figure 8.55 Stair directions and number of treads.

Noting Logic

The basic approach used for noting (notation) logic is to show a complete set of working drawings as if a complete set of specifications were included. **Specifications** are the written documentation of what is drafted; they give information that is not given in the drawings. Brand names, model numbers, installation procedures, and quality of material are just a few of the items included and discussed in a set of specifications. Thus, inclusion of the specifications affects the noting on the floor plan.

Because of the precise descriptions contained in the specifications, only general descriptions are necessary on the floor plan. For example, it is sufficient to call out a "cooktop" as a generic name and let the specifications take care of the rest of the description. "Tub" and "water closet" are sufficient to describe plumbing fixtures.

Because further description would only confuse the drawing, these items should be described in the specifications (*specs*). In other words, specific information should not be duplicated. If it is, changes can present problems. For example, suppose brand "A" is selected for a particular fixture and is called out as brand "A" on the floor plan rather than by its generic term. Later, it is changed to brand "B." Now both the floor plan and specs must be changed; if one is missed, a discrepancy that can cause confusion results.

Electrical Rating

Many architectural firms that superimpose the electrical plan on top of the floor plan note the **electrical rating** necessary for a particular piece of equipment; for example, range 9KW, oven 5KW, dishwasher 1.5KW, and refrigerator 110 V. Electrical ratings can also be included in an electrical appliance schedule if one exists. It is important to track electrical ratings so as not to overload a circuit and trip the circuit breaker, or cause snow to appear on the TV screen every time you use, say, a dishwasher.

Room Sizes

Because sizes of rooms are often found on presentation drawings (scaled drawings), some people think that sizes of rooms (9 × 12, 10 × 14) belong on a floor plan. *They do not*. These approximate sizes are fine for client consumption, but are useless in the construction process.

Providing Satisfactory Dimensions

One of the most common criticisms from the field (workers on the job) is that the floor plans do not contain enough dimensions. Because these people cannot scale the drawings (something we would not want them to do anyway), they are dependent on dimensions; be sure they are all included! Remember that notes take precedence over the drawing itself. If a member is called a 2 × 10 but is drawn as a 2 × 8, the note takes precedence.

Sampling of Other Types of Floor Plans

Not all floor plans fit on a sheet, even a 36 × 48 sheet. The Vista del Largo structure is a good example. To maintain readability, the plan was cut in half, and it uses a key plan at a very small scale located on the bottom right corner of the sheet to show how the cut was made and how to reassemble it. Look at Figure 8.56.

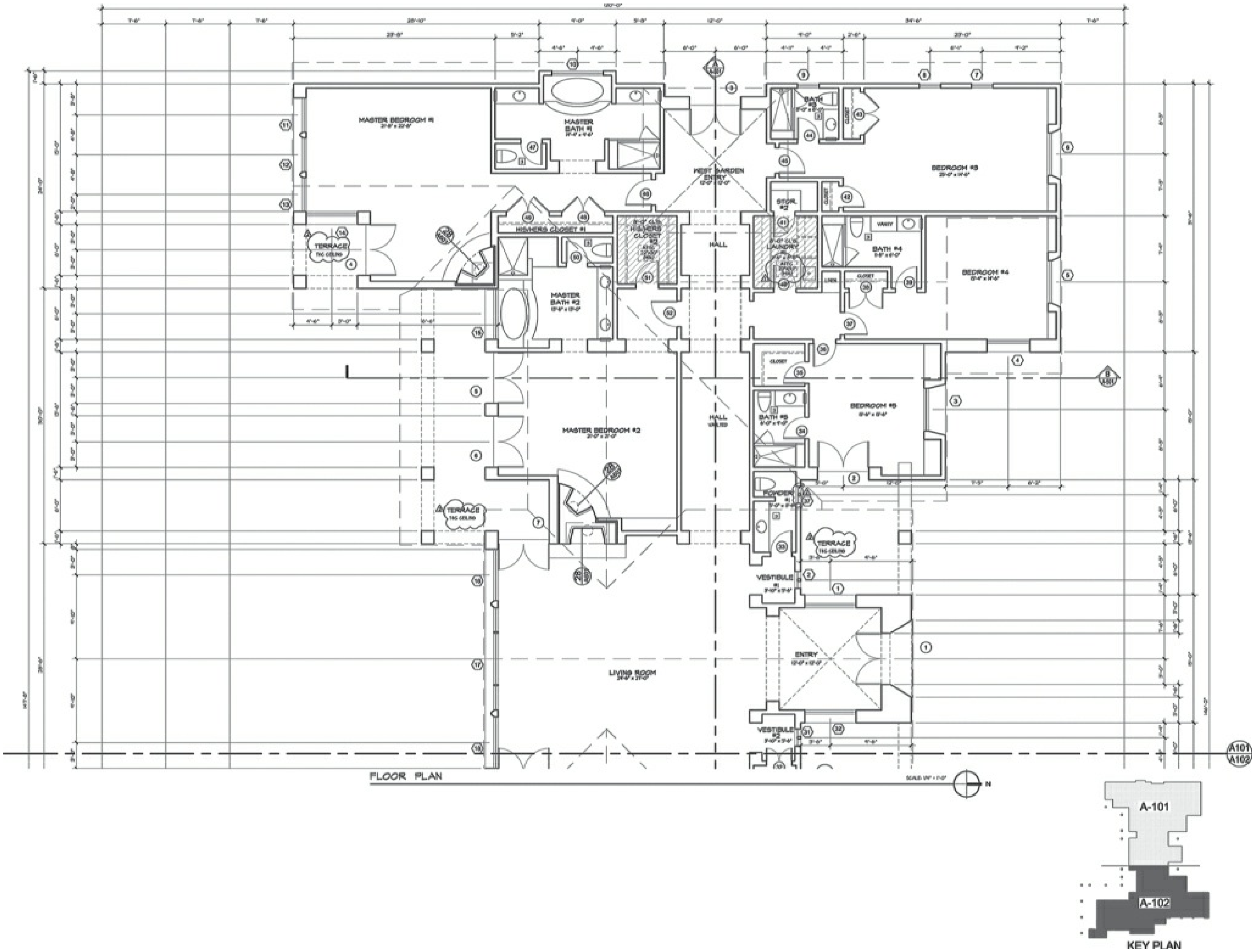
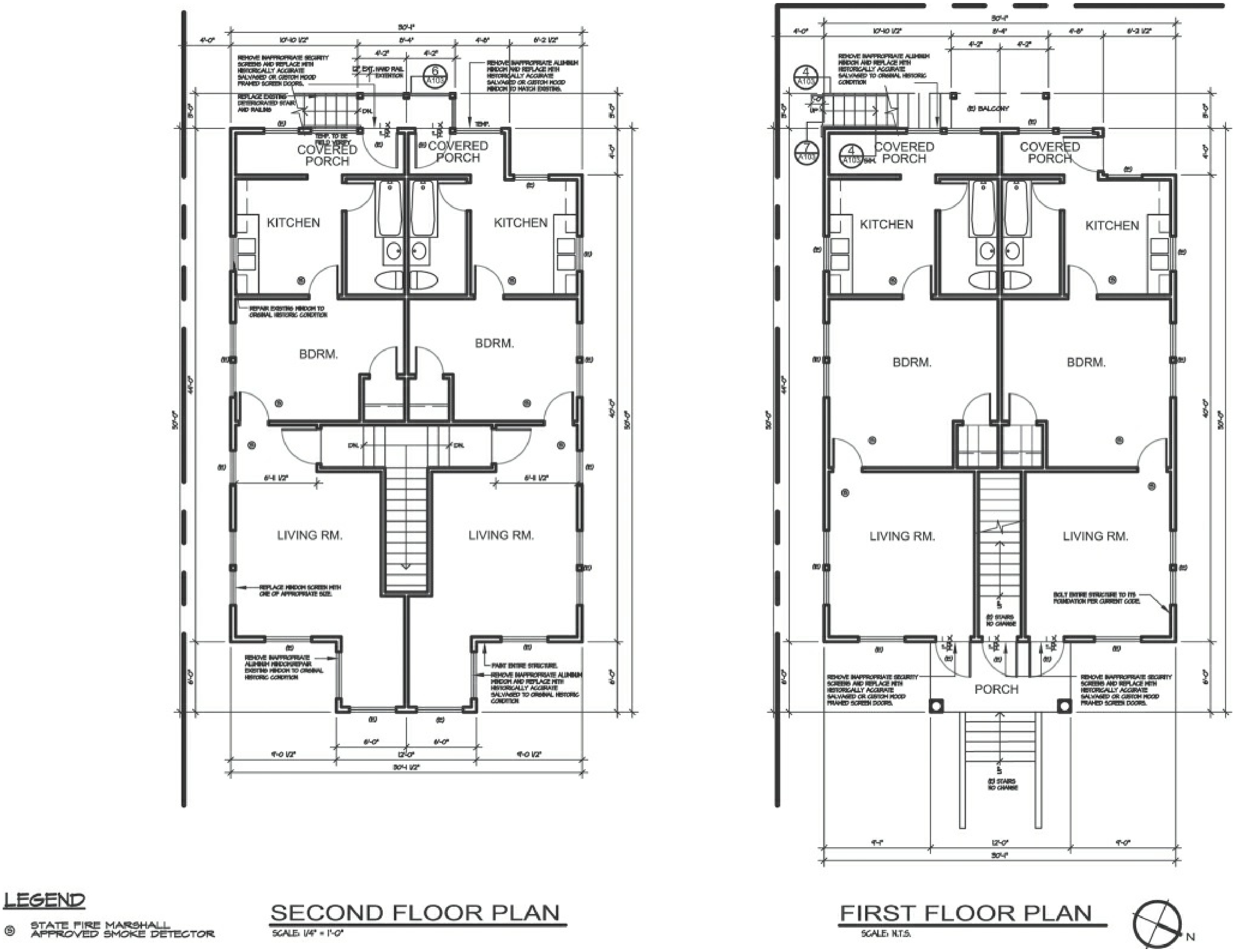


Figure 8.56 Vista del Largo: Split floor plan with key plan.

A structure such as the Costa home, which falls into the category of a restoration drawing, is seldom seen in the field of architecture relative to the percentage of drawings produced. See Figure 8.57.



[**Figure 8.57**](#) Historical building restoration drawings.

Also rarely used is a space plan that shows furniture for a residence; this does, however, give the client a better understanding of the physical constraints and benefits of the structure. See [Figure 8.58](#). However, it is a good plan to superimpose an electrical plan over such a space plan for the simple reason that, based on the furniture layout, an electrical plan can be developed from it. For an example, see [Figure 8.59](#).

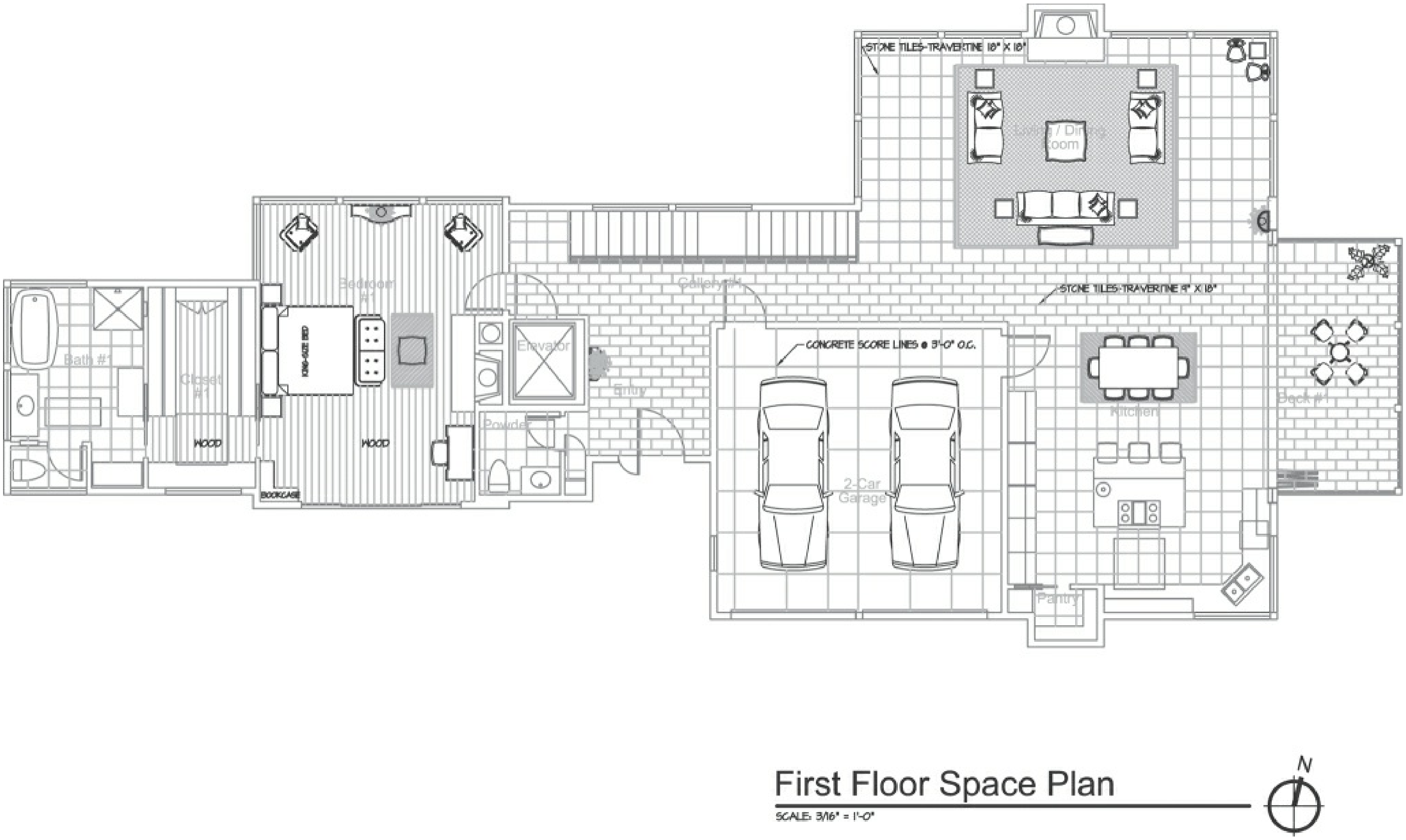


Figure 8.58 Colinita residence: Furniture plan.

(Courtesy of Colinita residence.)

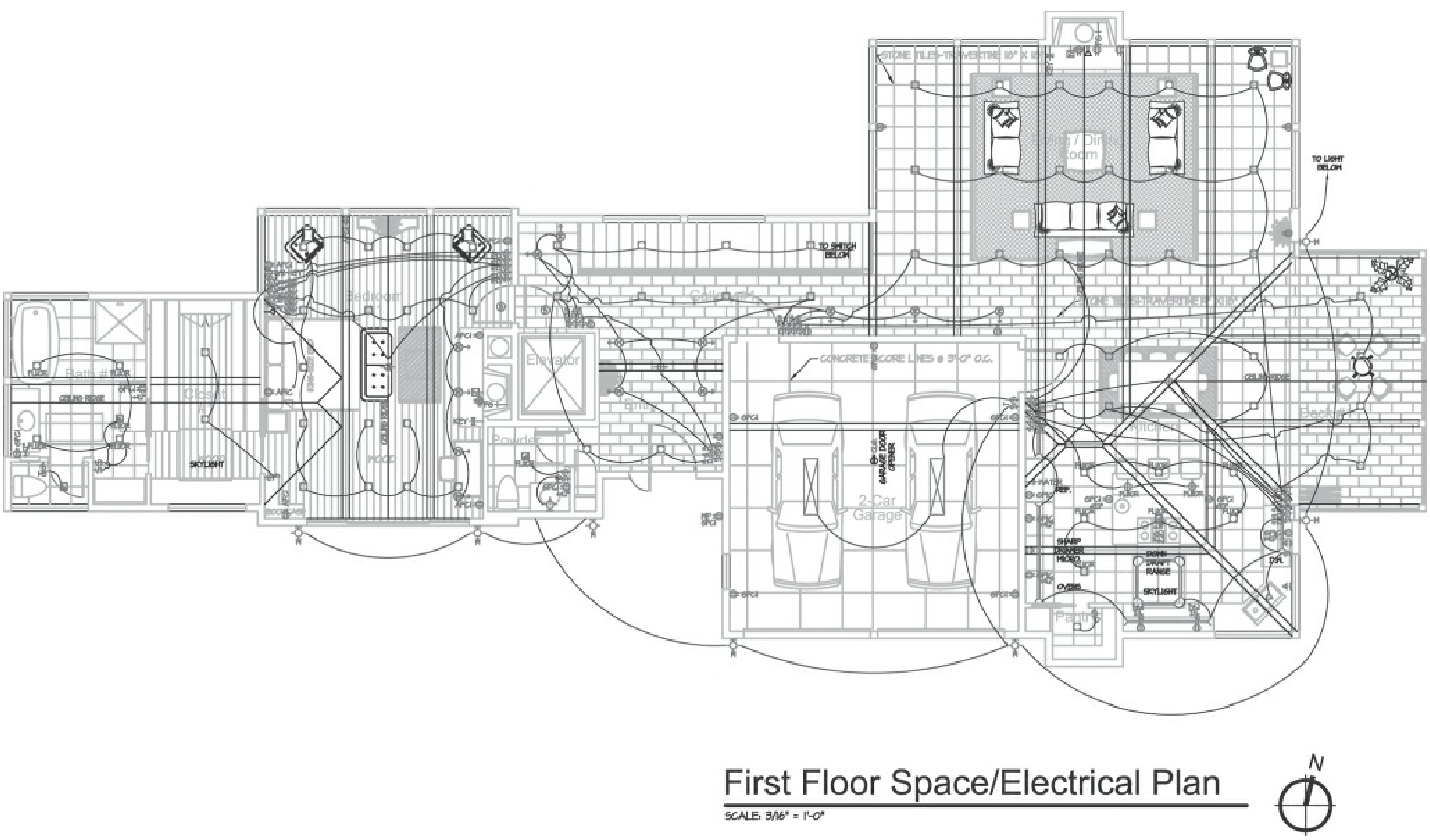


Figure 8.59 Colinita residence: Electrical plan based on furniture plan.

(Courtesy of Colinita residence.)

A good example of a small commercial plan appears in Figure 8.60. In this figure, we are looking at Grand Park Plaza, which is a steel structure of mixed use; it ties in a commercial venture that is also mixed use. In Japan, we find buildings in which the basement is used for parking, the first floor as a supermarket, the following floors for shopping, and the top floors for food courts or a children's playground.

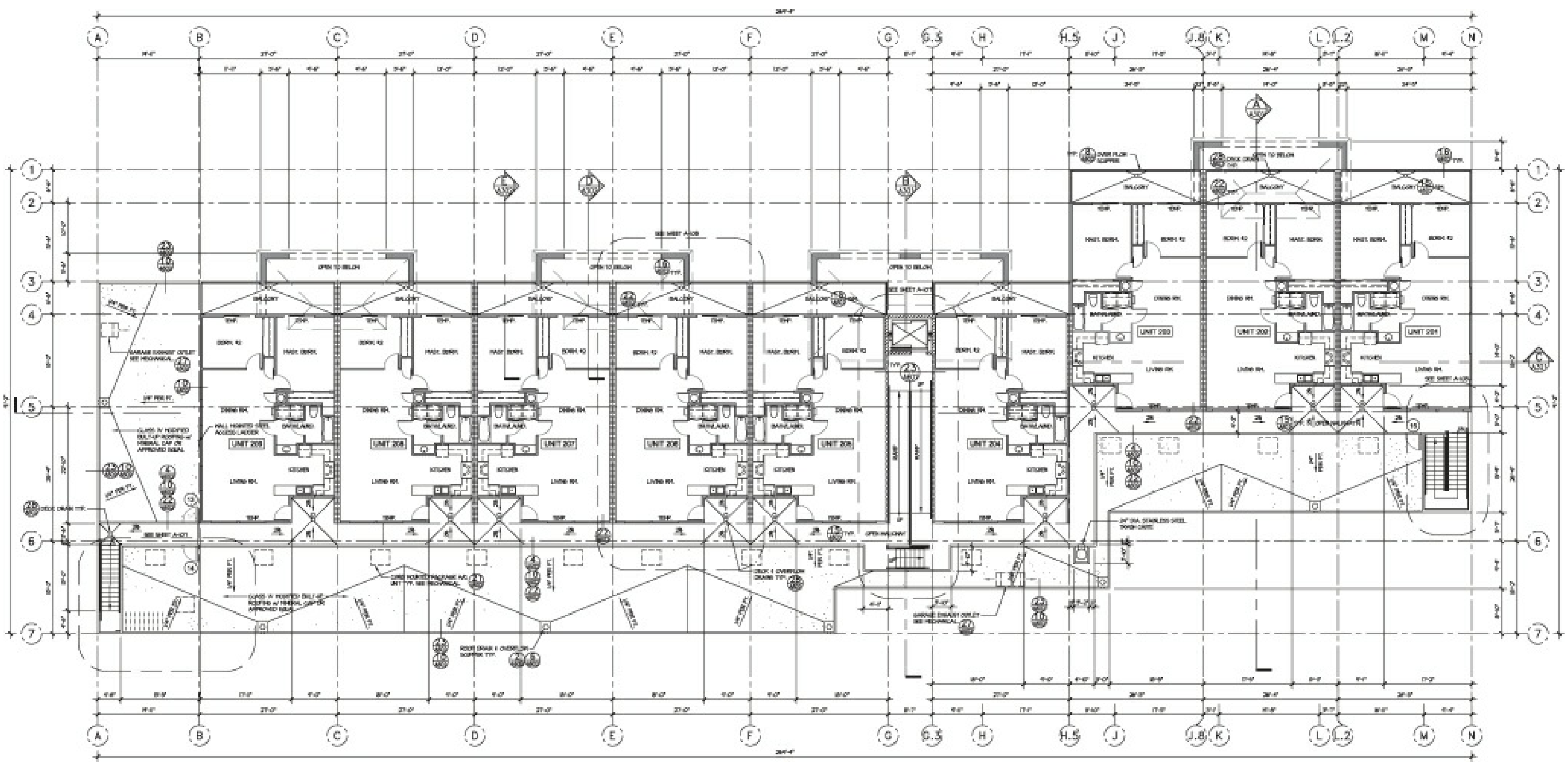


Figure 8.60 Commercial plan: Grand Park Plaza.

(Courtesy of Mr. Kizirian.)

Checklist: Checking Your Own Drawing

There are so many minute details to remember in the development of a particular drawing that most offices have worked out some type of checking system. A **checklist** (or check sheet) is one frequently used device. It lists the most commonly missed items in chart form, making it easy for you to precheck your work before a checker is asked to review a particular drawing. See Figure 8.61 for a floor…plan checklist.

OTHER FLOOR PLAN CONSIDERATIONS

1. Walls
    a. Accuracy of thickness
    b. Correctness of intersections
    c. Accuracy of location

   d. 8…inch wall
   e. Openings
   f. Pony walls designated
   g. Poché
2. Doors and windows
   a. Correct use
   b. Location
   c. Correct symbol
   d. Schedule reference
   e. Header size
   f. Sills, if any
   g. Show swing
   h. Direction of slide if needed
3. Steps
   a. Riser and treads called out
   b. Concrete steps
   c. Wood steps
4. Dimensioning
   a. Position of line
   b. All items dimensioned
   c. All dimensions shown
   d. All arrowheads shown
   e. Openings
   f. Structural posts
   g. Slabs and steps
   h. Closet depth
   i. Check addition
   j. Odd angles
5. Lettering
   a. Acceptable height and appearance
   b. Acceptable form

    c. Readable
6. Titles, notes, and call…outs
    a. Spelling, phrasing, and abbreviations
    b. Detail references
    c. Specification references
    d. Window and door references
    e. Appliances
    f. Slabs and steps
    g. Plumbing fixtures
    h. Openings
    i. Room titles
    j. Ceiling joist direction
    k. Floor material
    l. Drawing title and scale
    m. Tile work
        1. Tub
        2. Shower
    n. Attic opening—scuttle
    o. Cabinet
    p. Wardrobe
        1. Shelves
        2. Poles
    q. Built…in cabinets, nooks, tables, etc.
7. Symbols
    a. Electric
    b. Gas
    c. Heating, ventilating, and air conditioning
8. Closets, wardrobes, and cabinets
    a. Correct representation
    b. Doors
    c. Depths, widths, and heights

   d. Medicine cabinets
   e. Detail references
   f. Shelves and poles
   g. Plywood partitions and posts
   h. Overhead cabinets
   i. Broom closets
9. Equipment (appliances)
   a. Washer and dryer
   b. Range
   c. Refrigerator
   d. Freezer
   e. Oven
   f. Garbage disposal
   g. Dishwasher
   h. Hot water
   i. Forced draft vent
10. Equipment (special)
   a. Hi…Fi
   b. TV
   c. Sewing machine
   d. Intercom
   e. Game equipment (built…in)
   f. Other
11. Legend
12. Note exposed beams and columns
13. Special walls
   a. Masonry
   b. Veneers
   c. Partial walls, note height
   d. Furred walls for plumbing vents
14. Note sound and thermal insulation

15. Fireplaces
    a. Dimension depth and width of fire pit
    b. Fuel gas and key
    c. Dimension hearth width
16. Mail slot
17. Stairways
    a. Number of risers
    b. Indicate direction
    c. Note railing
18. Medicine cabinet, mirrors at bath
19. Attic and underfloor access ways
20. Floor slopes and wet areas
21. Hose bibbs
22. Main water shut…off valve
23. Fuel gas outlets
    a. Furnace
    b. Range
    c. Oven
    d. Water heater
    e. Fireplace
24. Water heater: gas fired
    a. 4” vent through roof
    b. 100 sq. in. combustion air vent to closet
25. Furnace location: gas fired
    a. Exhaust vent through roof
    b. Combustion air to closet
26. Electric meter location
27. Floodlights, wall lights, note heights
28. Convenience outlets, note if 220 V, note horsepower if necessary
29. Note electric power outlets
    a. Range 9 KW

b. Oven 5 KW
c. Dishwasher 1.5 KW
d. Refrigerator 110 V
e. Washer 2 KW
f. Dryer 5 KW

30. Clock, chime outlets
31. Doorbell
32. Roof downspouts
33. Fire extinguishers, fire hose cabinets
34. Interior bathroom, toilet room fans
35. Bathroom heaters
36. Kitchen range hood fan and light
37. Telephone, television outlets
38. Exit signs
39. Bathtub inspection plate
40. Thermostat location
41. Door, window, and finish schedules
42. Line quality
43. Basic design
44. Border line
45. Title block
46. Title
47. Scale

Figure 8.61 Floor…plan checklist.

DRAWING A FLOOR PLAN WITH A COMPUTER

The procedure for drawing a floor plan on a computer is somewhat different from that normally used only a few years ago to draw a floor plan manually. However, the information placed on the floor plan, as well as the dimensioning techniques and the formal representations used, remain valid for construction purposes.

The floor plan should be layered out on the grid the designer used. The structure may be

built on a 4… or 5…foot grid, and this grid should be drawn on the datum layer. If there is no set module, the datum grid can be set to 1… or 2…foot increments (see Figure 8.62). If the structure is built of masonry, there may be a block module to which this grid can be set.

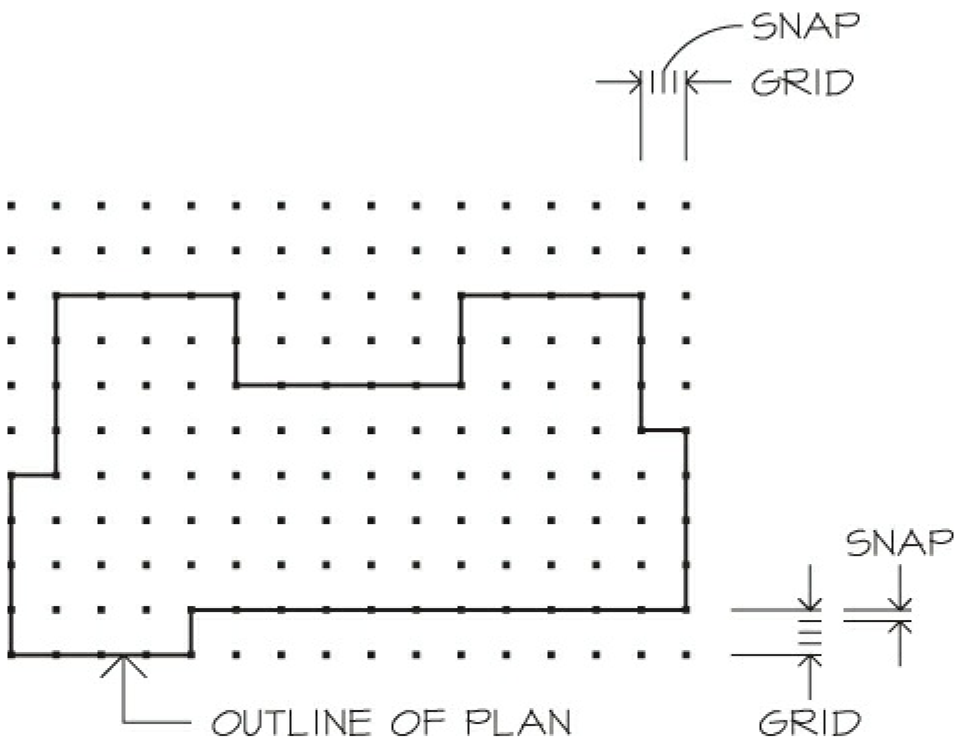


Figure 8.62 Setting grids and snaps to a module.

Multiples of 16″ have become a favorite spacing, inasmuch as most building products come in multiples of 16″. Thus, 16, 32, and 48 become easy modules to locate. In working with steel, the columns may be set to a larger grid, such as 12′…6″ spacing. If the grid is this large, set your snaps (spacing where the cursor will momentarily stop) to a smaller spacing. If you are rounding off walls to the nearest 3″, then 3″ will be a good distance to set your snaps. In dimensioning conventional stud construction, the snap should be set at 1″, allowing the drafter to dimension to the face of stud (FOS) (see Figure 8.63).

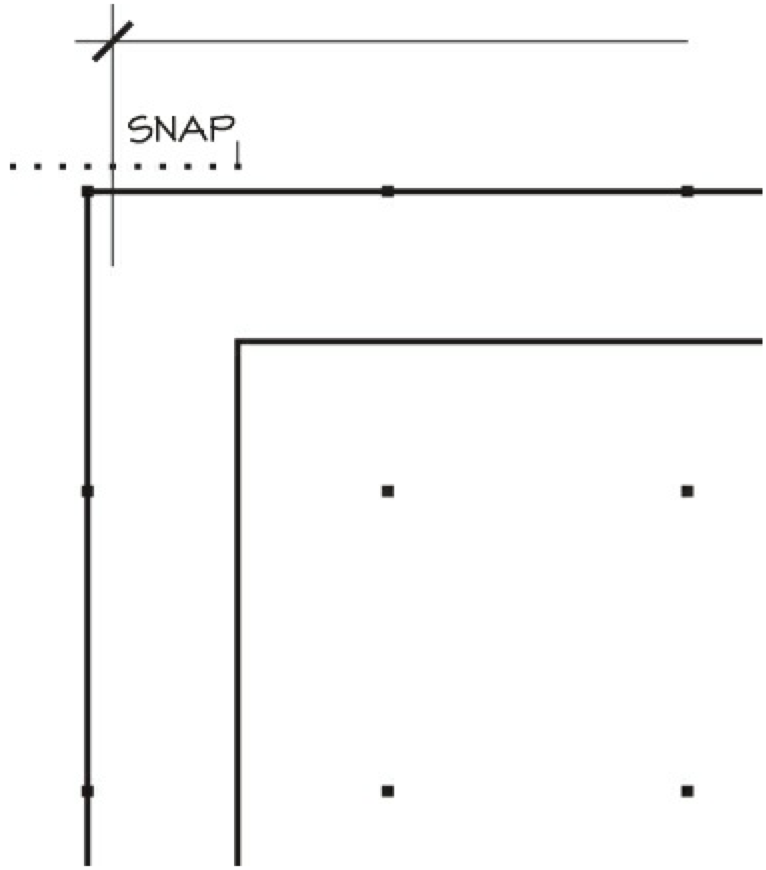


Figure 8.63 Grid versus snap.

Let us take a look at the computer drawings, done in six stages, for the first…floor plan of the Adli residence. Remember, you may need more than 10 layers to accomplish these six stages.

Stage I (Figure 8.64). This is the most critical stage because it sets the field of work and the basic outlines for the structure. If we were working with steel, the columns would be set and positioned during this stage. The properties of the outline can be listed, so that plan users can immediately find the square footage of the structure and its perimeter. This outline can be used to position the structure on the site, to verify the required setbacks, or to compare this figure with the allowable buildable area of a particular site.

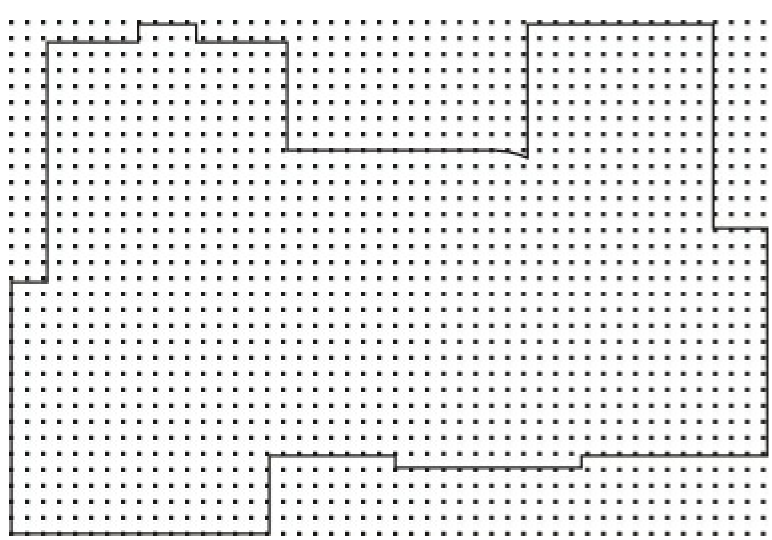


Figure 8.64 Stage I: Setting the datum and building outline.

Stage II ([Figure 8.65](#)). All walls are established at this stage. Exterior walls and interior bearing walls can be put on one wall layer, and all non…bearing walls can be placed on a secondary wall layer. Column locations and all openings are drawn on still another layer. Openings for doors and windows may also be placed on separate layers. Completion of this stage may produce four to six layers. Preliminary energy calculations can be done easily at this stage.

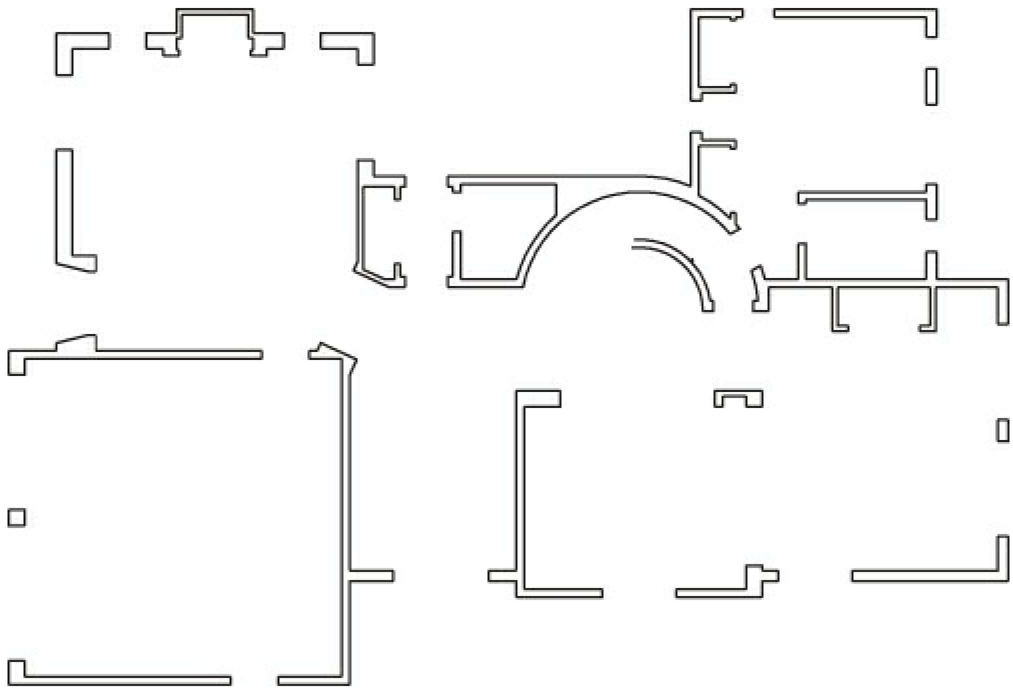


Figure 8.65 Stage II: Exterior/interior wall and openings.

Stage III ([Figure 8.66](#)). At this stage, door and window conventions are drawn, along with any connectors such as for stairs, ramps, escalators, elevators, and lifts. Partitions for office layouts are done now, as well as indications for plumbing fixtures such as sinks and toilets, and built…in cabinets such as kitchen cabinets, shelves and poles in wardrobe closets, built…in bookcases, reference tables, and the like.

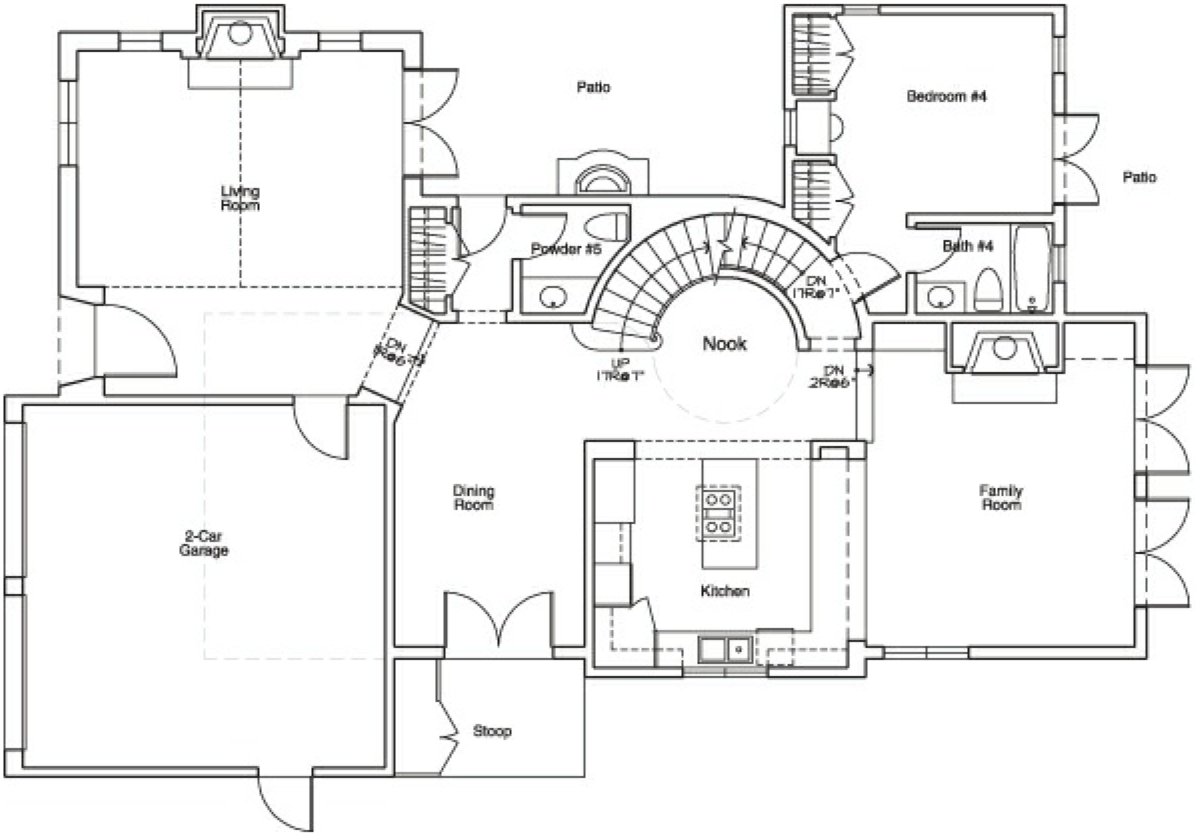
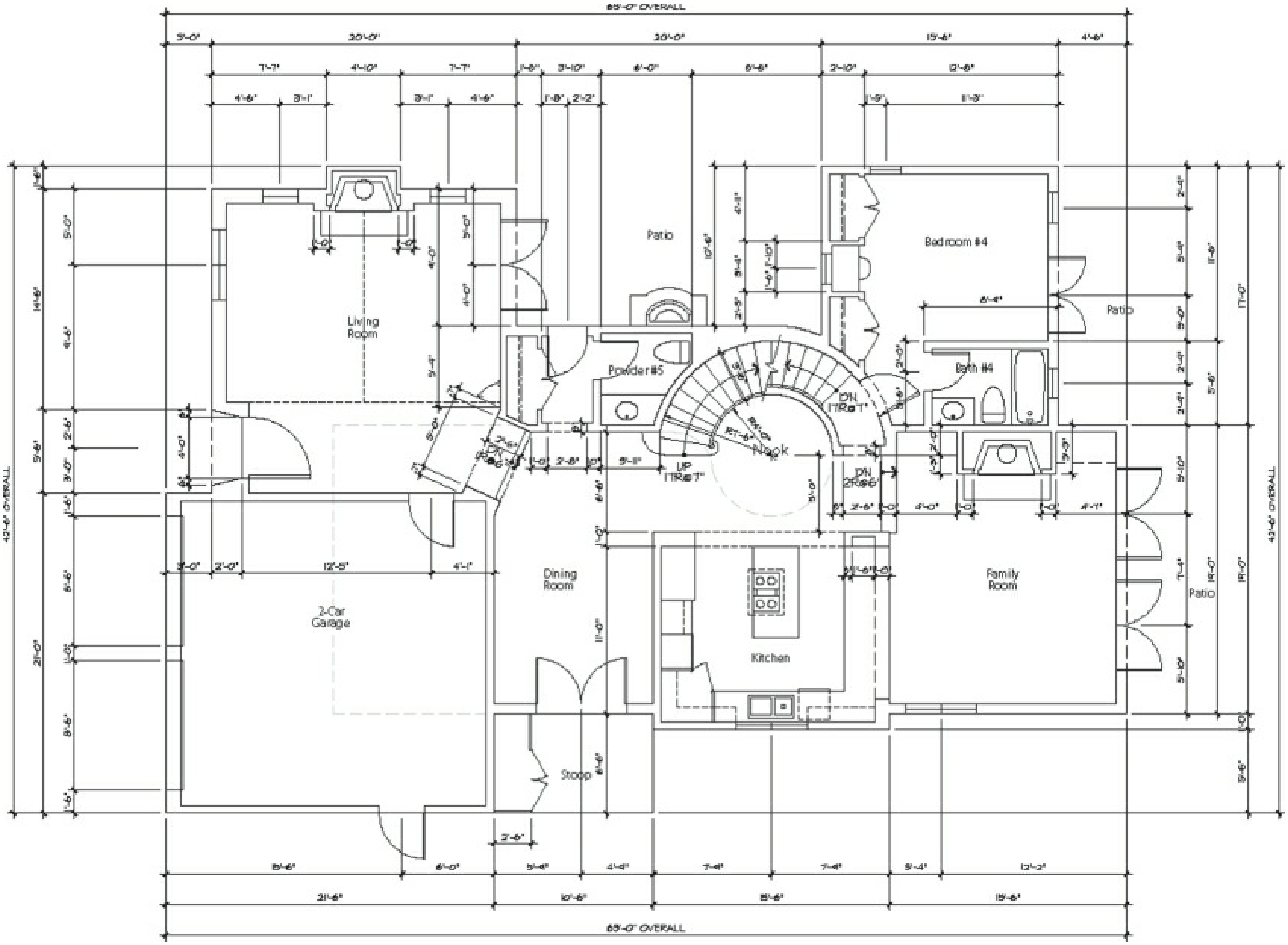


Figure 8.66 Stage III: Plumbing fixtures, stairs, windows/doors, and partitions.

Stage IV (Figure 8.67). This is the sizing and location stage. All the necessary dimensioning is done now. You must verify block modules and stud…line dimensioning, or adhere to the dimensional reference system if one is being used. Work to numerical values (maximum and minimum) and tolerances to which the workers in the field can build.



[Figure 8.67](#) Stage IV: Dimensioning.

Stage V ([Figure 8.68](#)). This could easily be called the communication stage, because what is produced in this stage must communicate with all the other drawings. Reference symbols are used to connect one drawing with another. Detail references, reference to schedules, and building section reference bubbles are drawn at this stage. This allows the reader to look to other sources for additional information about a portion of the floor plan. Section symbols refer us to the multiple building sections throughout this plan. Detail reference bubbles explain in greater detail the nature of the cabinets and columns and how they are connected with other structural members. Interior elevation reference bubbles show, for example, how a fireplace may be finished, or the appearance of cabinets in an examination room of a medical facility; they can also be used to reference windows and doors to schedules for size or for details on the physical makeup of a particular window or door.

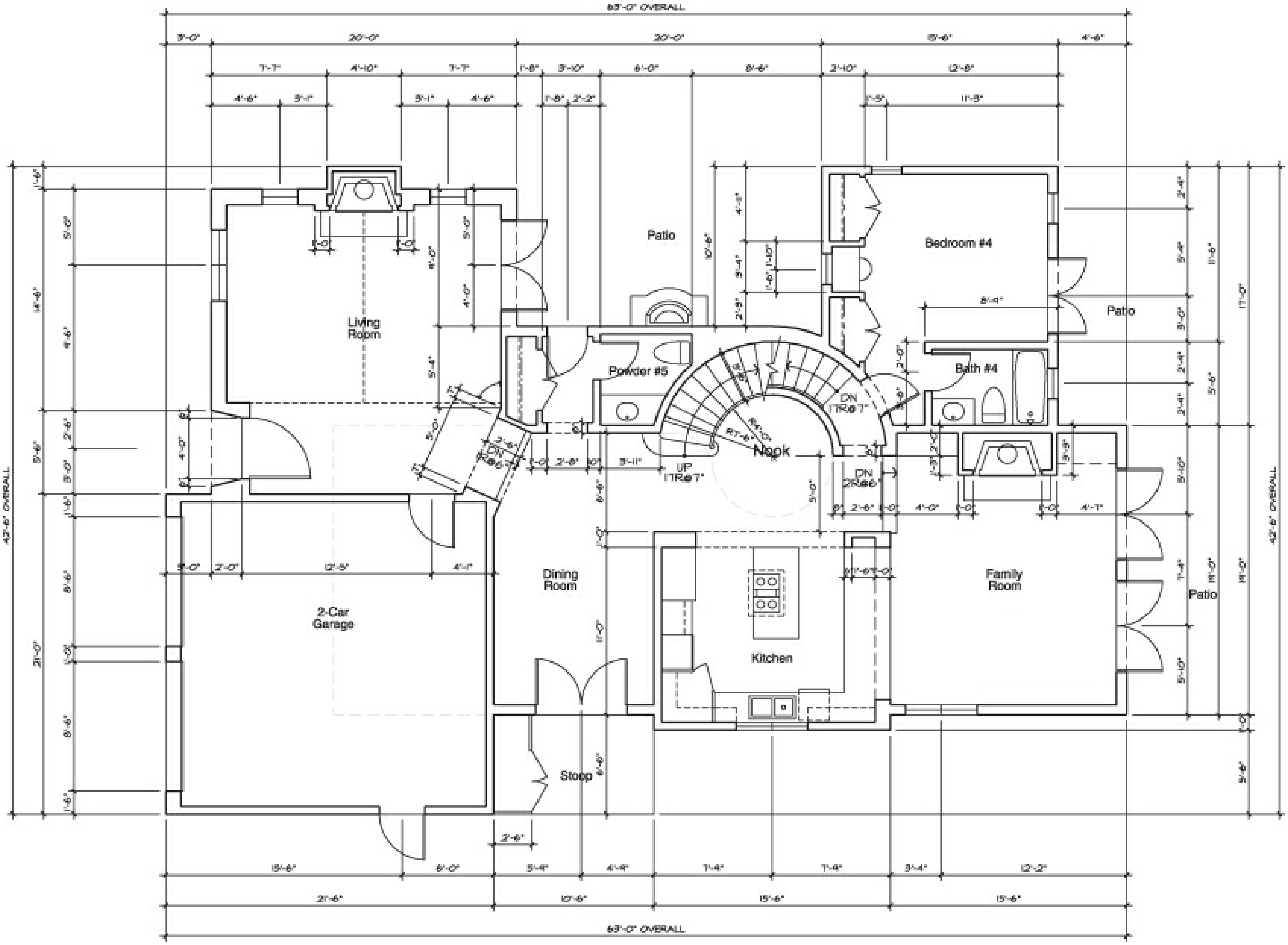
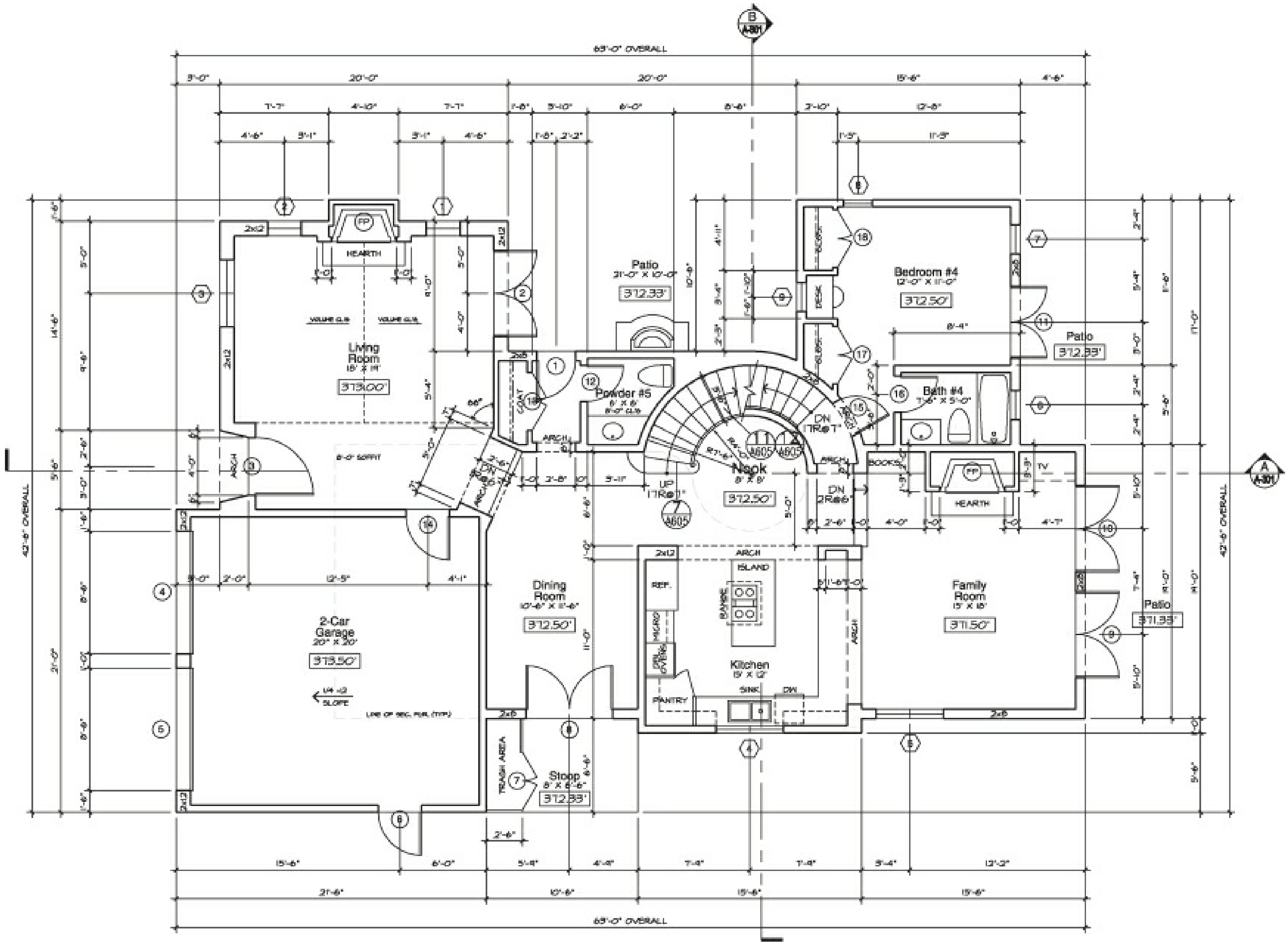


Figure 8.68 Stage V: Noting and references, both detail and section.

Stage VI (Figure 8.69). All noting and titles are added in this stage, but in many instances the designer may have inserted the room titles when presenting the floor plan to the client. These titles may be relocated at this stage, for clarity, so that they do not interfere with the dimensions, appliances, and so forth. Room titles can be placed on one layer, and other notes, such as those identifying columns or materials, can be placed on another layer. Lettering size may be a determinant for the different layers or the font being used. Main titles should be of existing fonts in the computer program, and all construction notations should be done with an architectural lettering font for ease of correction.



[Figure 8.69](#) Stage VI: Finish work—titles, poché, scale.

(Courtesy of Mike Adli, owner.)

Creating a Floor Plan

Producing the Floor Plan. One will think that if you were familiar with AutoCAD that the technological information would transfer to the new programs that are being used. The new programs are using a completely different vocabulary and are asking the technical drafter to know more about architecture. Most noteworthy about the new programs is their ability to catch human error. This is because the newer programs do not draw plans individually but draft the entire building three…dimensionally, including a description of the individual components that make a wall, such as the studs and the insulation. In AutoCAD, you draw individual drawings (floor plan, elevations, sections, etc.), whereas in Revit you draw the entire model of the building in 3…D and then develop, for example, the floor plan, dimensioning, and notes; validate wall locations; and so on. You do this two…dimensionally while thinking in three dimensions, so all of the information in this chapter is valuable. The conventions are standard.

Catching human error is not as easy or complete as it might sound. If you put in the

wrong dimension, as in Figure 8.70, and your original intent was to make wall "A" parallel with "B" and "C," Revit will not do so. In keeping with the dimensions you entered, the top wall will be dimensioned from face of stud to center of wall, whereas the dimension on the bottom is dimensioned from face of stud to face of stud. On a 2 × 4 system, this creates a discrepancy of 1¾″. In trying to position this wall, the computer will slide the one wall over 1¾″. To repair this, the original walls ("B" and "C") must be drawn parallel in the original building model and dimensioned later. However, unlike AutoCAD, Revit will dimension to a stud line.

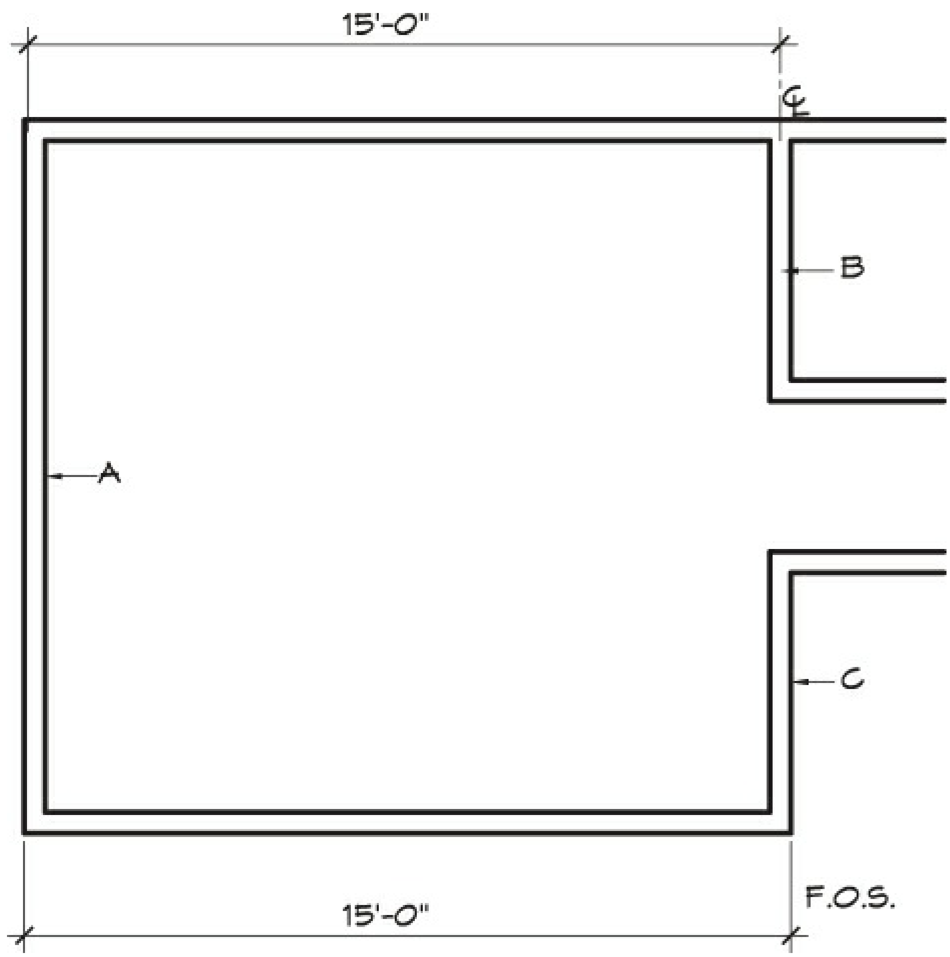


Figure 8.70 Positioning a wall on the floor plan.

If a change is made to a floor plan, such as the location of a door or window, Revit will reflect this change in all other drawings, such as the elevation section, framing plans, and so on. However, if the building were a six…story structure, a change in the first…floor plan window would not carry over to or appear on the second…floor plan or other floor plans. If you intended for the windows to be aligned vertically, it would be best to make the change on the exterior elevation, whereupon all subsequent floor plans would be changed.

You must build the template of a floor plan based on what is standard in our industry. A template should work as well in New York as in California, in Alabama as in England, and in France as in China. You may work on buildings in Texas, but what you draw should be understood all over America or Asia or Europe if you are to become a master of our profession.

Checklist—Floor Plan

1. Visualize the task at hand. Is it modeling or annotation? If you are a drafter or designer, be sure you understand the important parts of this structure that should not be compromised.
2. If there is a module or pattern, set the grid.
3. Refine the grid by setting up a snap.
4. If annotating, set up your monitor so you can see if there is any impact on the model… use viewports, and/or use two monitors.
5. Review AIA standards and align drawings with its standards.
6. Be sure to make a drawing template.
7. You cannot create a template as you build your first set of drawings on Revit. Build a template before you begin your first Revit drawings.
8. Be sure the massing model is complete before you begin construction drawings.
9. Check special items that are required by the planning department and/or building department.

Troubleshooting a Floor Plan

1. Always enlarge the drawings to locate walls that are misaligned. Make any necessary corrections before you dimension.
2. Check to see that the floor plan, along with its dimensions, notes, and title, will fit on the drawing sheet. If it does not, a scale change is one option; drawing the two halves of the plan on two separate sheets with a key plan is an alternate choice.
3. Make sure you have the proper material designations to complete a specific job.
4. Ensure that you have enough space to comply with the axial reference. Plan on the correct spacing between the dimension lines and the structure.
5. Check that you have correctly employed line qualities.
6. Ensure that section lines and other conventions were used correctly.

CASE STUDIES: WORKING DRAWING DEVELOPMENT

In this section, we discuss the development of the floor plan working drawings for the Clay Theater a Steel and Masonry Building.

Design Development

Even in the development stage, you need to know more about the finished product than about drawing methods. For example, for this theater project, we needed to learn (to mention just a few items):

- What the client can supply, such as the proper slope of the stage, and other knowledge derived from years of building theaters
- Volume and size of the concession area
- Whether the client approves of video games (determines whether a game arcade becomes part of the theater)
- The local and regional building codes applicable to the proposed site
- All about cars:
  - Turn radius
  - Parking requirements
  - Ratio of compact versus regular stalls
  - Aisles required between rows of cars
  - Parking required for disabled patrons
- Dedicated green space—minimum required and optimum
- Environmental concerns and elements to be designed in anticipation of the future

Of course, this is above and beyond the aesthetic building form, “normal” environmental concerns, concepts, essence, and so on that dictate the spirit and parti (essence in drawing form).

Before Working Drawings

As you finish the so…called initial schematic studies, you must put the information in a performance stage, solving each of the views you will need for the working drawings. Resolve the problem of the pilaster (widening of the block wall) and its connection with the roof. Do the same with the wall of the second floor and the roof, and the connection of the columns to the roof. This is when you will consult associates regarding conflicts of the paths for the structural work, mechanical (e.g., ductwork) installations, plumbing, and so on.

Resolve the easement (right…of…way for the electrical utility) that runs across the site. This is a very good time to cut the major and minor sections through the building and decide which interior elevations you will need to show. Add the various engineering, mechanical, and lighting drawings, and you will have a project browser that is nearly a parametric modeler.

Clay Theater—Steel/Masonry Structure

Ground…Floor Plan. The floor plan is the base datum from which all other drawings are established. It is also the first preliminary drawing to be used. It must be done comprehensively and adhere to all of the principles of drawing.

Stage I

The floor plan is taken from the preliminary floor plan because it is usually the first to be laid out. Thus, this stage must acknowledge the material that will be used to construct the building. In this instance, 8″ × 8″ × 16″ concrete blocks are used. Thus, when drawing the floor plan on the computer, a grid and snap must be built to the block module. See Figure 8.71 for an example of a block module chart. A chart similar to this one can be obtained from any of the manufacturers or associations that produce masonry units. A suggested layer might be set up with the grid set to 16″ increments and the snap set to 8″. The layout of Stage II will conform to this module.

BLOCK MODULE

(3/8" HORIZONTAL AND VERTICAL MORTAR JOINTS)

LENGTH	NO. 16" LONG BLOCKS	LENGTH	NO. 16" LONG BLOCKS
0'-8"	1/2	20'-8"	15 1/2
1'-4"	1	21'-4"	16
2'-0"	1 1/2	22'-0"	16 1/2
2'-8"	2	22'-8"	17
3'-4"	2 1/2	23'-4"	17 1/2
4'-0"	3	24'-0"	18
4'-8"	3 1/2	24'-8"	18 1/2
5'-4"	4	25'-4"	19
6'-0"	4 1/2	26'-0"	19 1/2
6'-8"	5	26'-8"	20
7'-4"	5 1/2	27'-4"	20 1/2
8'-0"	6	28'-0"	21
8'-8"	6 1/2	28'-8"	21 1/2
9'-4"	7	29'-4"	22
10'-0"	7 1/2	30'-0"	22 1/2
10'-8"	8	30'-8"	23
11'-4"	8 1/2	31'-4"	23 1/2
12'-0"	9	32'-0"	24
12'-8"	9 1/2	32'-8"	24 1/2
13'-4"	10	40'-0"	30
14'-0"	10 1/2	50'-0"	37 1/2
14'-8"	11	60'-0"	45
15'-4"	11 1/2	70'-0"	52 1/2
16'-0"	12	80'-0"	60
16'-8"	12 1/2	90'-0"	67 1/2
17'-4"	13	100'-0"	75
18'-0"	13 1/2	200'-0"	150
18'-8"	14	300'-0"	225
19'-4"	14 1/2	400'-0"	300
20'-0"	15	500'-0"	375

HEIGHT	NO. 4" HIGH BLOCKS	NO. 8" HIGH BLOCKS	HEIGHT	NO. 4" HIGH BLOCKS	NO. 8" HIGH BLOCKS
0'-4"	1		10'-4"	31	
0'-8"	2	1	10'-8"	32	16
1'-0"	3		11'-0"	33	
1'-4"	4	2	11'-4"	34	17
1'-8"	5		11'-8"	35	
2'-0"	6	3	12'-0"	36	18
2'-4"	7		12'-4"	37	
2'-8"	8	4	12'-8"	38	19
3'-0"	9		13'-0"	39	
3'-4"	10	5	13'-4"	40	20
3'-8"	11		13'-8"	41	
4'-0"	12	6	14'-0"	42	21
4'-4"	13		14'-4"	43	
4'-8"	14	7	14'-8"	44	22
5'-0"	15		15'-0"	45	
5'-4"	16	8	15'-4"	46	23
5'-8"	17		15'-8"	47	
6'-0"	18	9	16'-0"	48	24
6'-4"	19		16'-4"	49	
6'-8"	20	10	16'-8"	50	25
7'-0"	21		17'-0"	51	
7'-4"	22	11	17'-4"	52	26
7'-8"	23		17'-8"	53	
8'-0"	24	12	18'-0"	54	27
8'-4"	25		18'-4"	55	
8'-8"	26	13	18'-8"	56	28
9'-0"	27		19'-0"	57	
9'-4"	28	14	19'-4"	58	29
9'-8"	29		19'-8"	59	
10'-0"	30	15	20'-0"	60	30

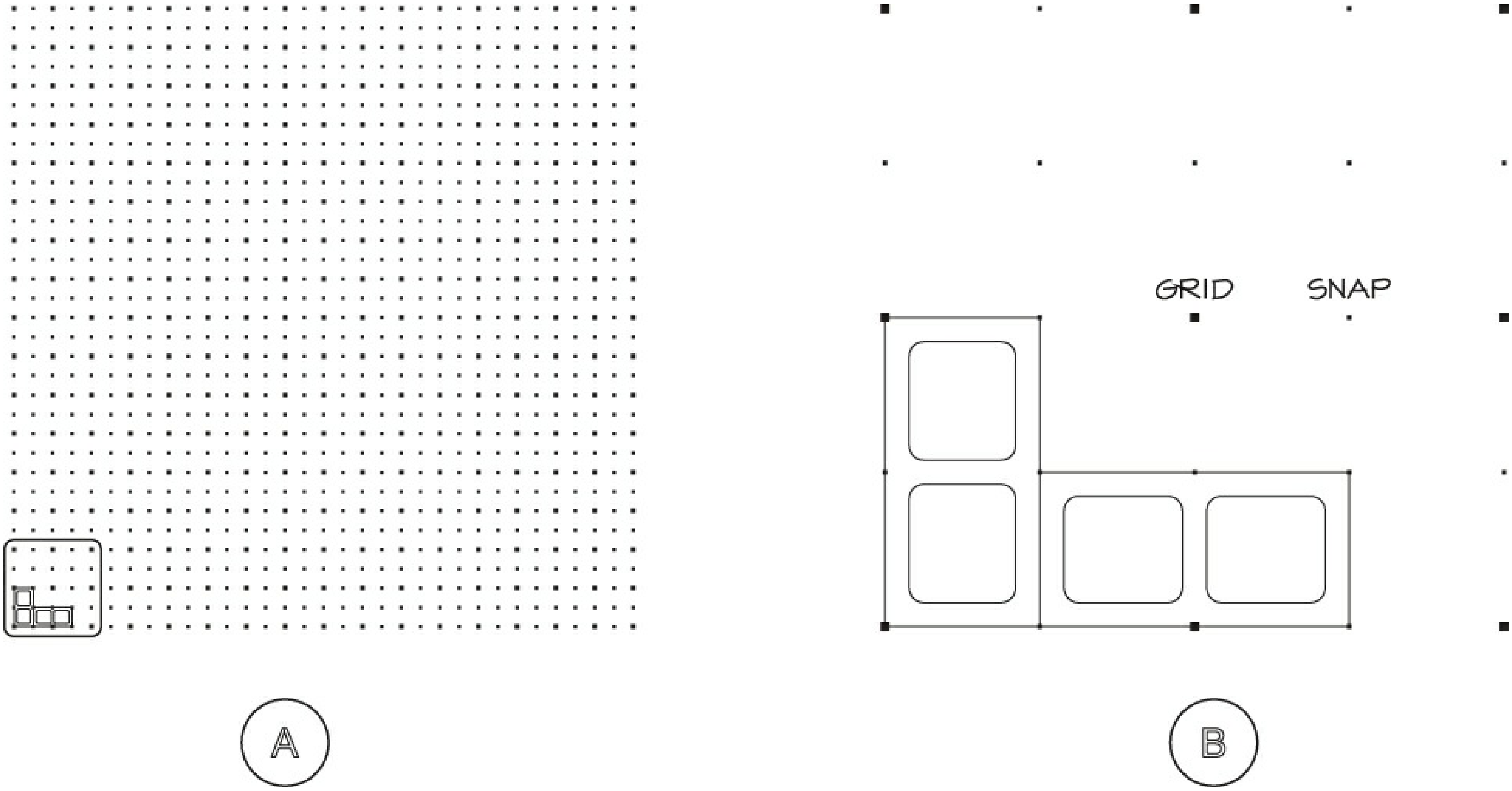


Figure 8.71 Grid and snap set to block module/block module chart.

Stage II

Clients may supply prototype plans based on their experience in a particular business. This particular client stated that this would be a six…theater structure with 200 seats in each theater. The level for each row of seats and fire restrictions were all design factors prior to the preliminary drawings.

Compare the aerial photograph in Figure 8.72 with Figure 8.73 to see what was actually being constructed. These figures show the construction sequence in relationship to the floor plan found in Figure 8.74.

Figure 8.72 Aerial view of completed wall.

(Reprinted with permission of William Boggs Aerial Photography.)

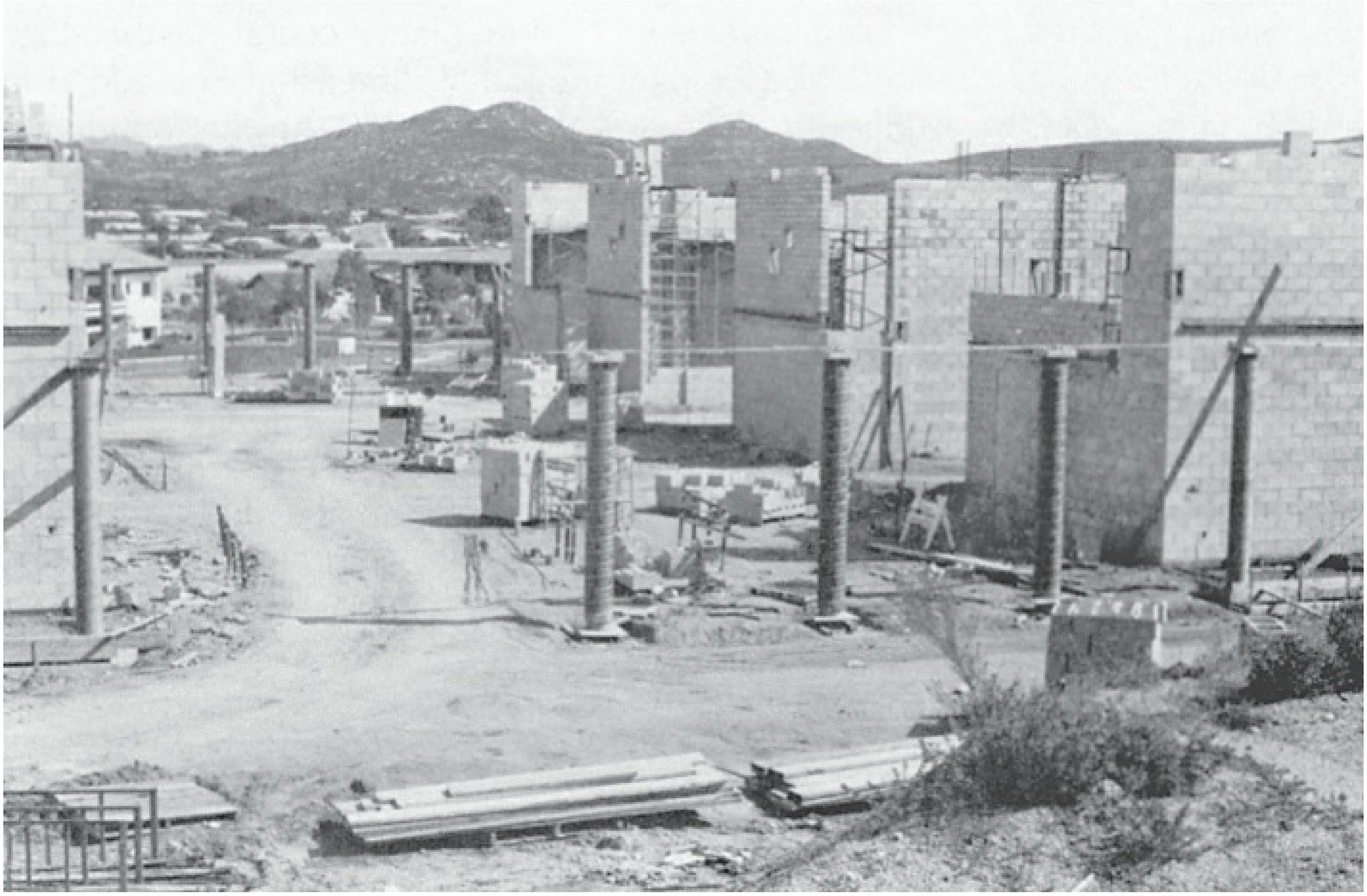


Figure 8.73 View of entry, lobby, and back of theaters.

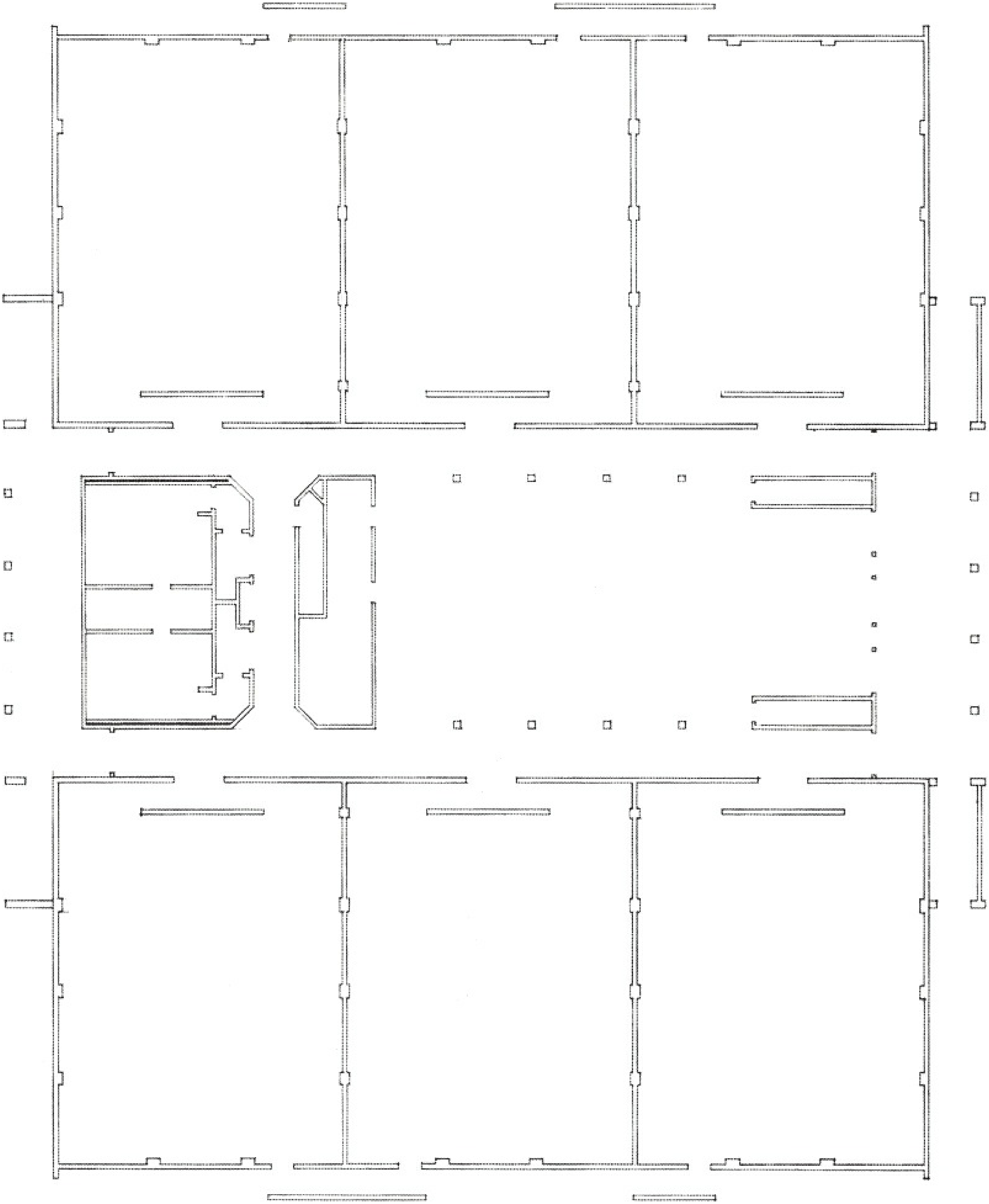


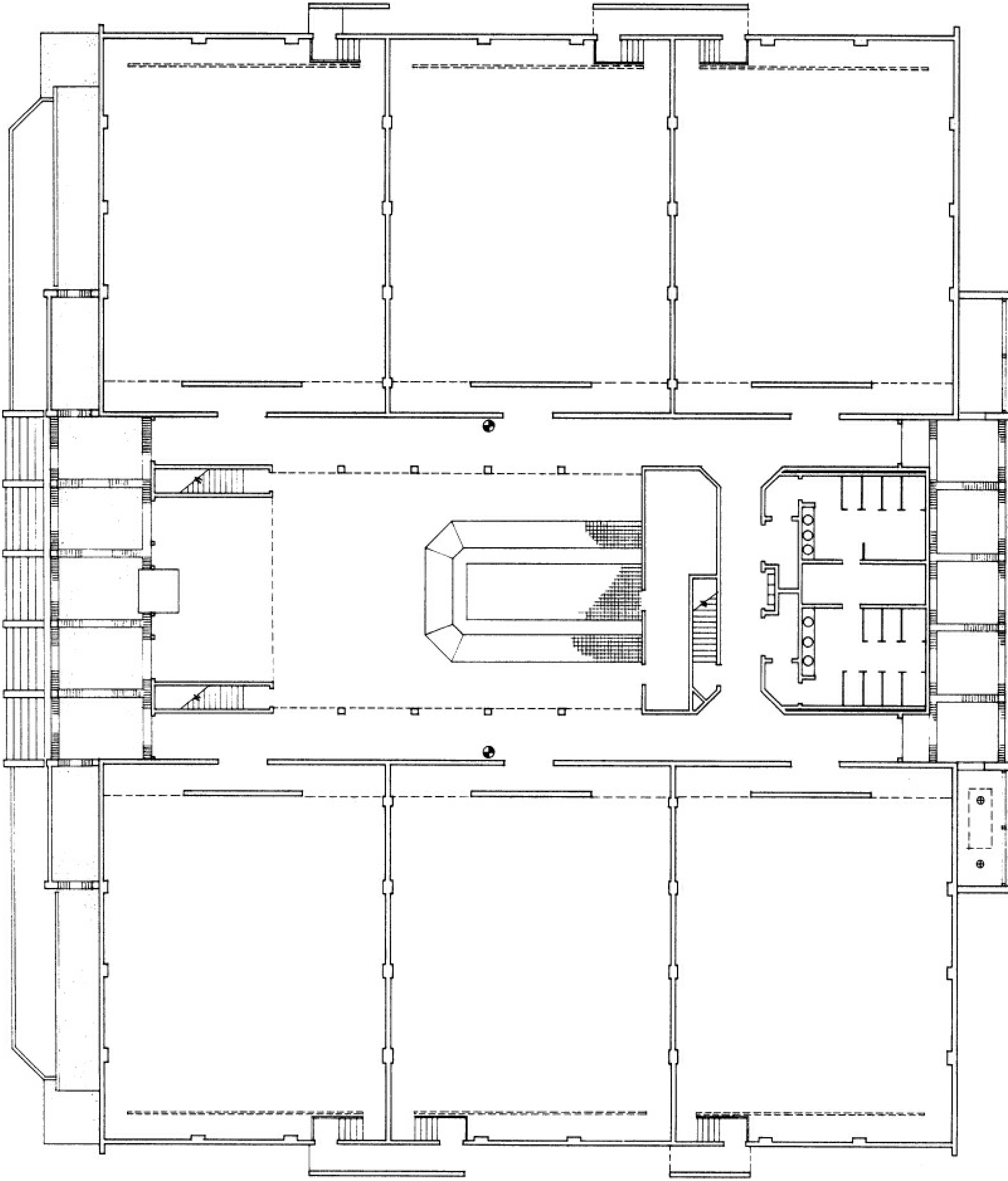
Figure 8.74 Clay Theater—Stage II: Working drawing—ground…floor plan.

In Figure 8.74 the columns toward the center of the theater support the upper floor. (The

upper floor accommodates the projectors and allows projectionist to move from one projector to another.) Near the rear of the building are the restrooms and snack bar storage. The two partial rectangles near the front of the theater are stairwells.

Stage III

At the bottom of the left and right sides of the plan, we added a planter and a ramp for disabled people. See Figure 8.75. Stairs were added throughout the plan and we added a set of dotted lines in each auditorium to represent the motion picture screens. The size of the screen was determined by the seating capacity and the client needs. Dividing walls were drawn within the stairs at the front. Notice at the front and rear of the building are brick pavers as described in the foundation plan (see Chapter 9). These pavers were drawn with textured concrete within them.



[**Figure 8.75**](#) Clay Theater—Stage III: Working Drawing...Ground Floor Plan.

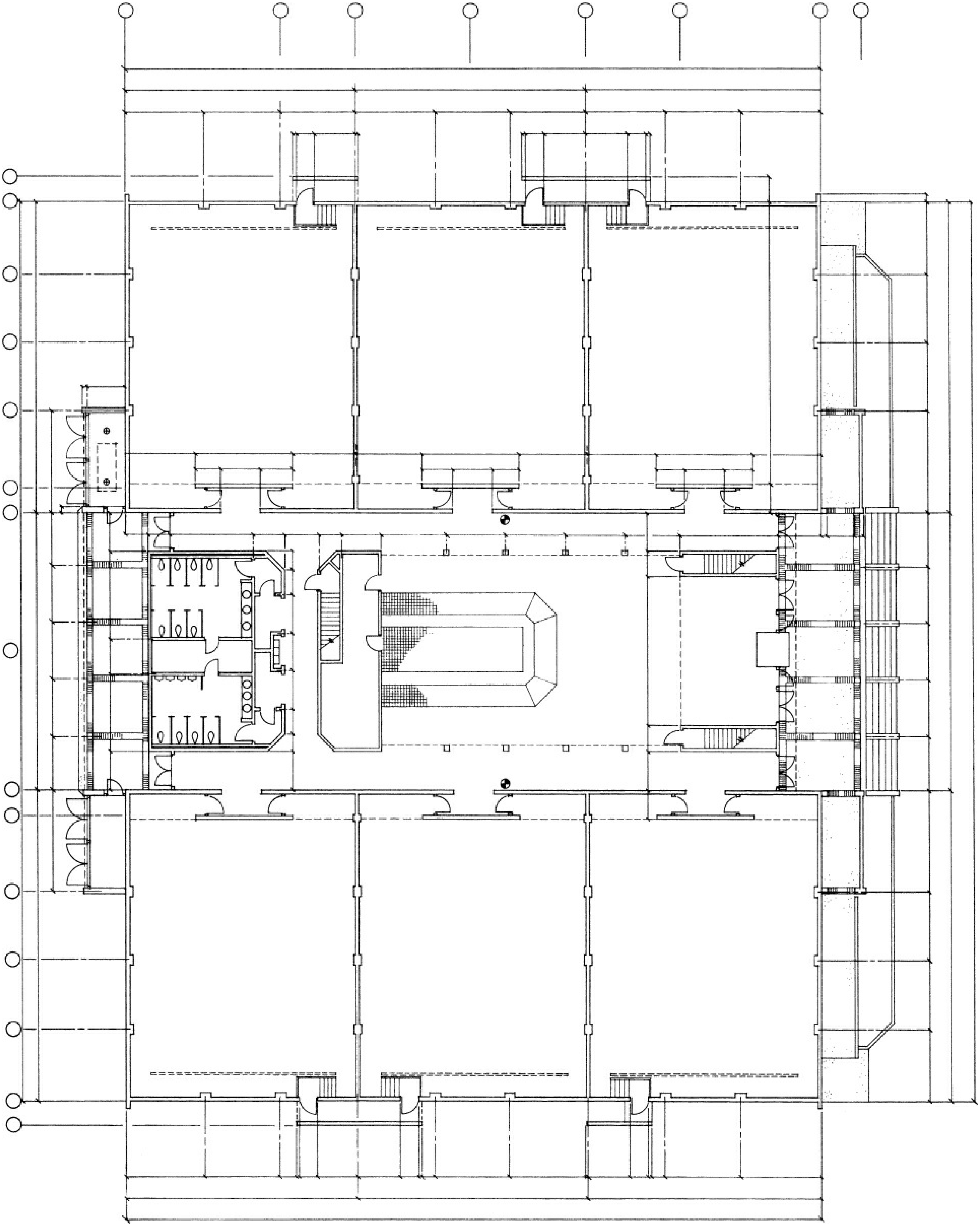
At the center of the structure is the concession stand. The textured area represents a tile floor and the black space, the counter. We added toilet partitions and lavatories to the

restrooms, leaving large stalls for persons with disabilities. Toilets can be added here later.

At the center of each restroom entry, the small area for telephones also accommodates disabled people. The small circles with a darkened cross indicate fire extinguishers. We added fire sprinkler symbols in the trash area in the rear of the building. Line quality becomes important here to differentiate between walls, floor patterns, and fixtures.

Stage IV

Interior and exterior dimension lines were now added, as shown in Figure 8.76. These dimension lines must always be double checked with the foundation plan, to ensure proper alignment of walls with the foundation. As the floor plan was dimensioned first, the concrete block module was followed.



[Figure 8.76](#) Clay Theater—Stage IV: Working drawing—ground…floor plan.

The axial reference plane bubbles across the top and the right correspond with walls, columns, and any structural members above. From the reference plane matrix, we also indicated door swings.

Stage V

All of the reference bubbles have now been added. See Figure 8.77. Full architectural section references, wall sections, door reference bubbles, and interior elevations reference symbols were included. Each room would later receive a number as well as title, so we drew in underlines for the names and rectangular boxes for the numbers.

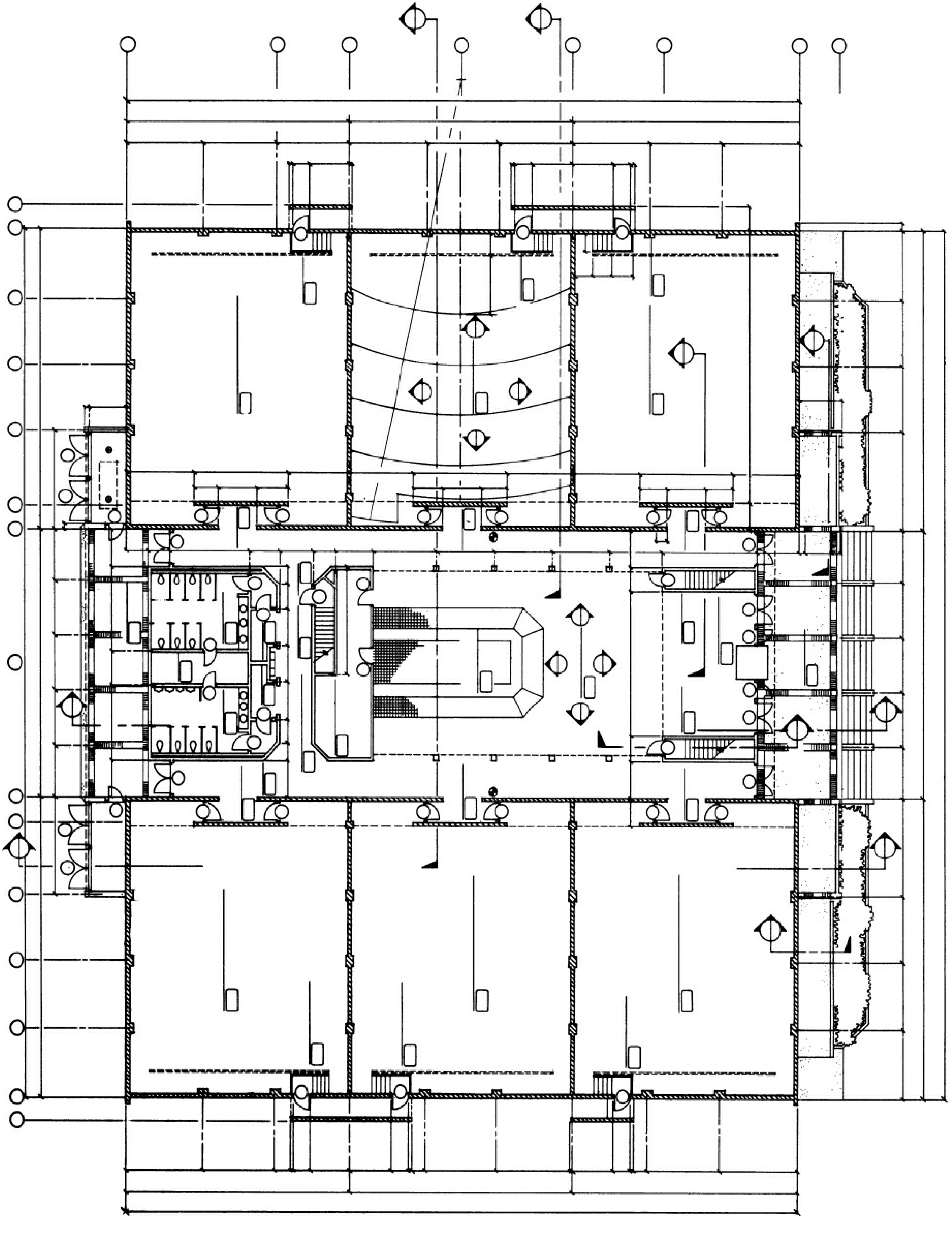


Figure 8.77 Clay Theater—Stage V: Working drawing—ground…floor plan.

We drew plants in the planters at the entry to clearly differentiate the planter areas from the ramps. The planters and plants were later included in the elevations for clarity and consistency.

The material designation for the walls indicated by hatching lines in the wall lines was drafted next.

For the final stage of the ground…floor working drawing, refer to Figure 18.77, where numerical values for the dimension lines were included, as well as the noting of items such as the pilaster size and location of screens, area, and room titles.

Finally, the drawing title, scale, and north arrow were also added at the final stage.

Upper_Floor Plan

Stage I

We included the six auditoriums in the upper…floor plan, as shown in Figure 8.78, because the upper portions of the auditorium were adjacent to the upper floor. The center of the structure is the lobby, which extends to the roof.

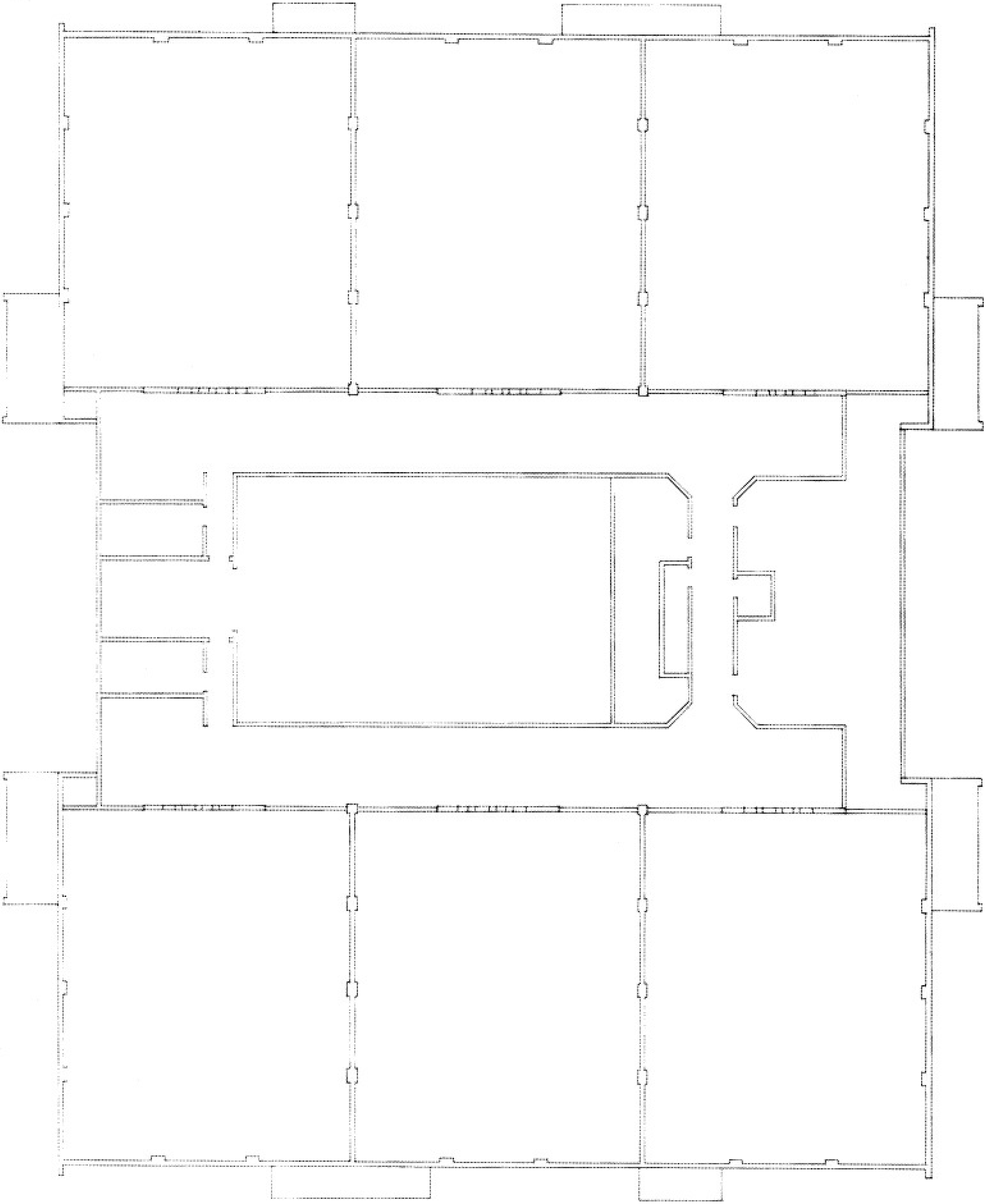


Figure 8.78 Clay Theater—Stage I: Working drawing—upper…floor plan.

We located the projection windows according to their required angle. See Figure 8.78,

which shows the interior of the structure. Note the projection windows and the connectors below to attach the upper floor. We took care to align the walls of the upper floor with the walls below.

Another view of this relationship can be seen in the structural section.

Stage II

This stage (Figure 8.79) shows the restroom facilities, two fire extinguishers (one circle on each side), and, most important, the projectors and the space they occupy. A rectangle with a line through it next to the circle was the symbol selected to represent the projectors.

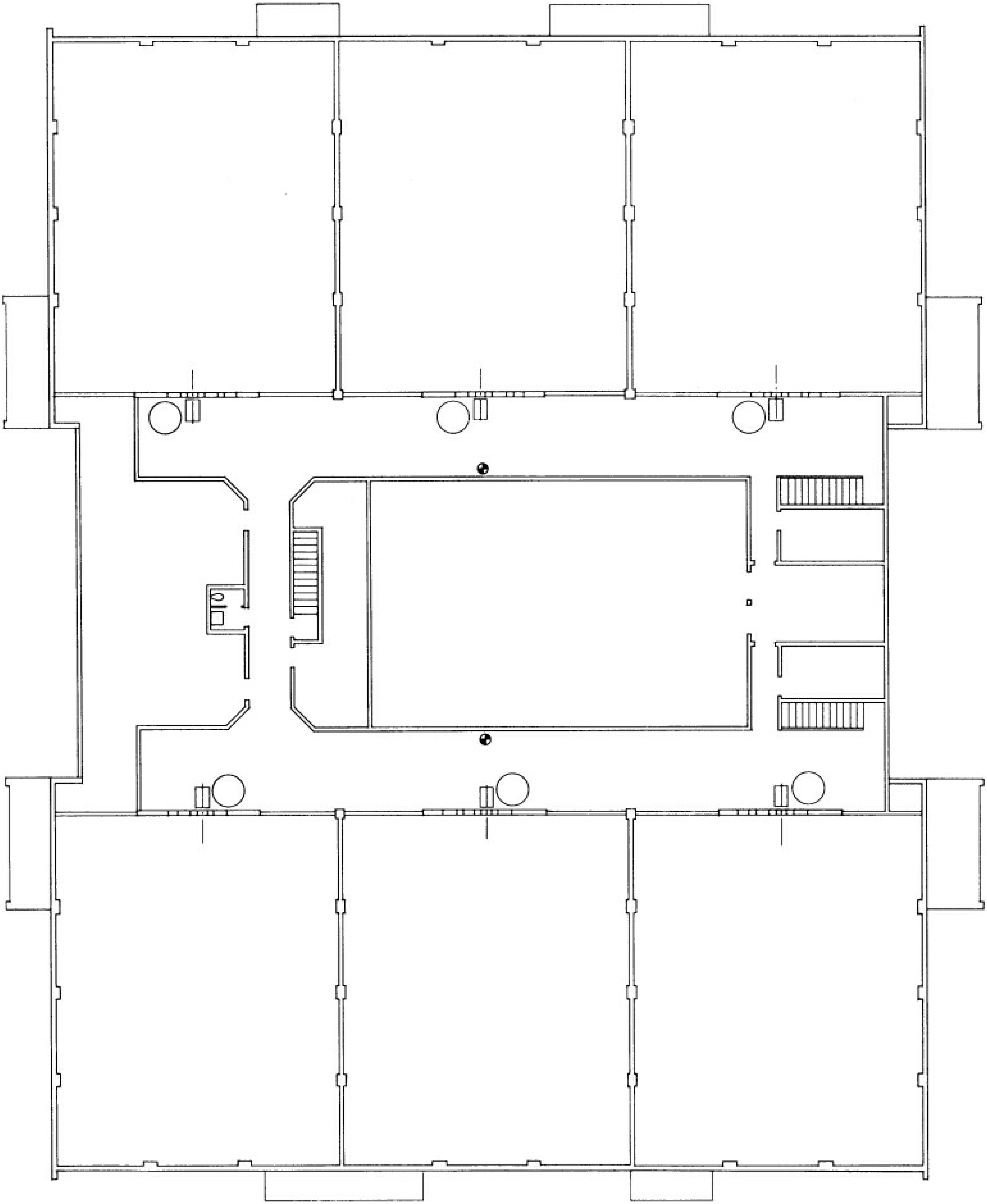


Figure 8.79 Clay Theater—Stage II: Working drawing—upper…floor plan.

Stage III

The main difference in this stage and previous stages is the addition of most of the dimension numbers. See Figure 8.80. The dimensions had to be checked against the floor plan of the floor below, and both had to be checked to ensure correct concrete block modules dimensions. For the final stage of the second…floor plan working drawing, refer to Figure 8.80.

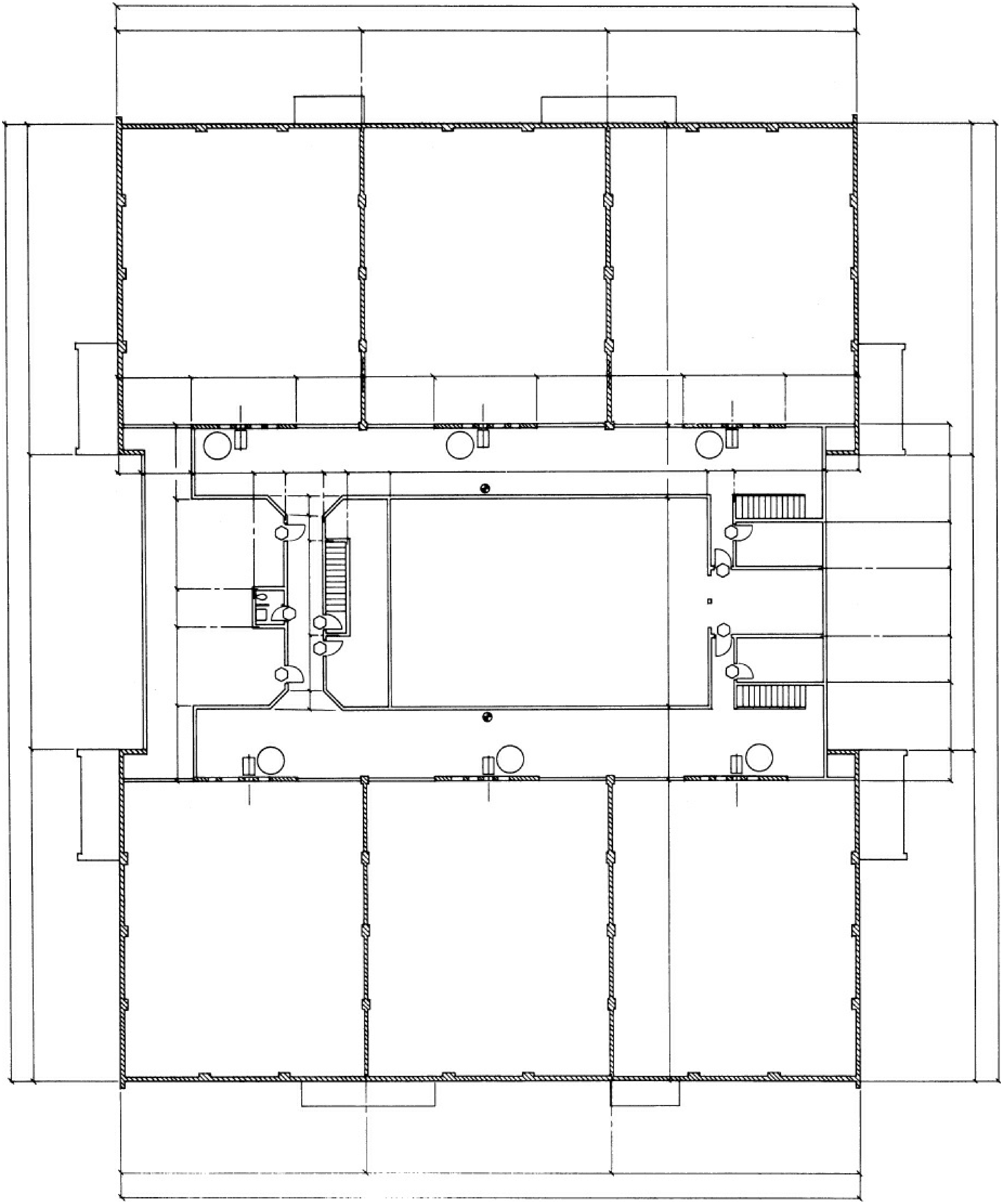


Figure 8.80 Clay Theater—Stage III: Working drawing—upper…floor plan.

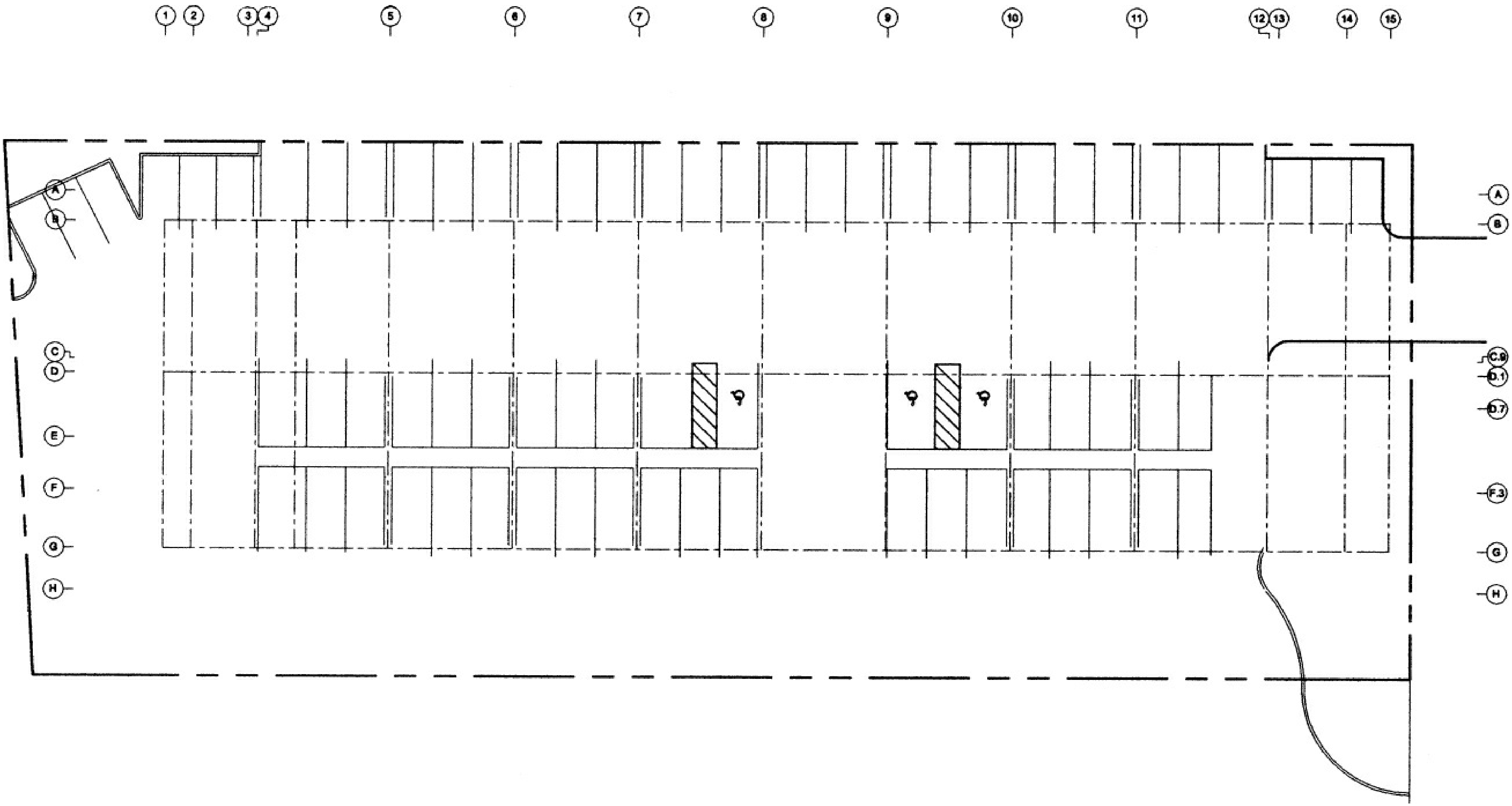
Madison—Steel Building

Ground‐Floor Plan

Stage I

The first step in the evolution of the working drawings was to precisely lay out the site plan, incorporating the parking stalls, traffic lanes, handicapped parking stall, and spaces for public access locations. These accurately scaled areas were predicated on the schematic studies of the site plan and the ground‐floor plan.

Once the accurately scaled parking stalls were located, the locations of the steel supporting columns could be established. From this drawing, a matrix identifying system designating the various column and wall locations was created. Refer to Chapters 2 and 3 for detailed information and explanations of the use of a matrix system. Figure 8.81 illustrates a site plan, parking layouts, and the initial structural matrix system with bubbles for the purpose of identifying the locations of the steel columns and wall. This drawing, which was prepared by the computed‐aided drafting (CAD) operator for the project, was the first and the basis for the additional layering of succeeding drawings that were used in developing the various floor levels for the completion of the working drawings. In general, the layering process for drawings is the evolution of a series of drawings that have been formatted from initial drawings, which become the basis for all succeeding drawings. For additional information relative to the layering process, refer to Chapter 3.



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
A
B
C
D
E
F
G
H
A
B
C.9
D.1
D.7
F.3
G
H

Figure 8.81 Madison Building—Stage I: Matrix system.

Stage II

From Stage I, a basic matrix system layout for all structural members was established in Stage II. This drawing became the primary structural template for all succeeding floors, incorporating the floor and roof framing plans, exterior elevations, and building sections. Note that on the west side matrix, there are symbols with a specific letter designation that may be followed by a number. This tells the viewer that there is an identifying wall located north of column “D.” The basic matrix layout template is depicted in Figure 8.82.

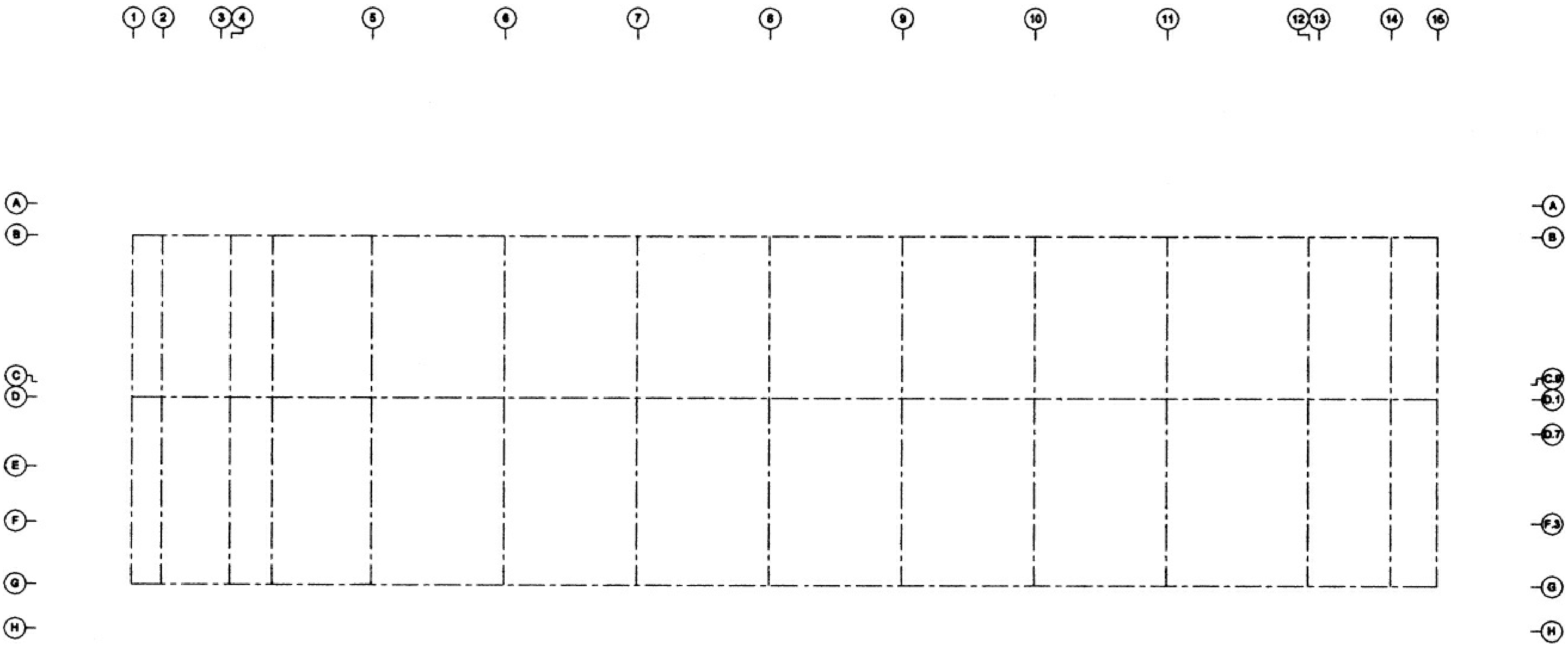

1
2
3
4
5
6
7
8
9
10
11
12
13
14
16
A
B
C
D
E
F
G
H
A
B
D.1
D.7
F.3
G
H

Figure 8.82 Madison Building—Stage II: Matrix template.

Stage III

With the combination of layering from Stages I and II, a third stage for the ground…floor plan was developed. This drawing illustrated the combination of the parking stalls, the matrix system, the supporting steel column locations, and the wall locations for public access and structural considerations. The drawing also defined the wall boundary location for the succeeding upper…floor levels. As a result of the early schematic drawings, elliptical wall shapes were incorporated into the stairwell walls and lobby locations at the west and east sides of the structure. In the main lobby area, which is located approximately in the center of the building, other spaces were established for facilities such as an elevator, stairwell, and machine and utility rooms. This drawing is shown in Figure 8.83.

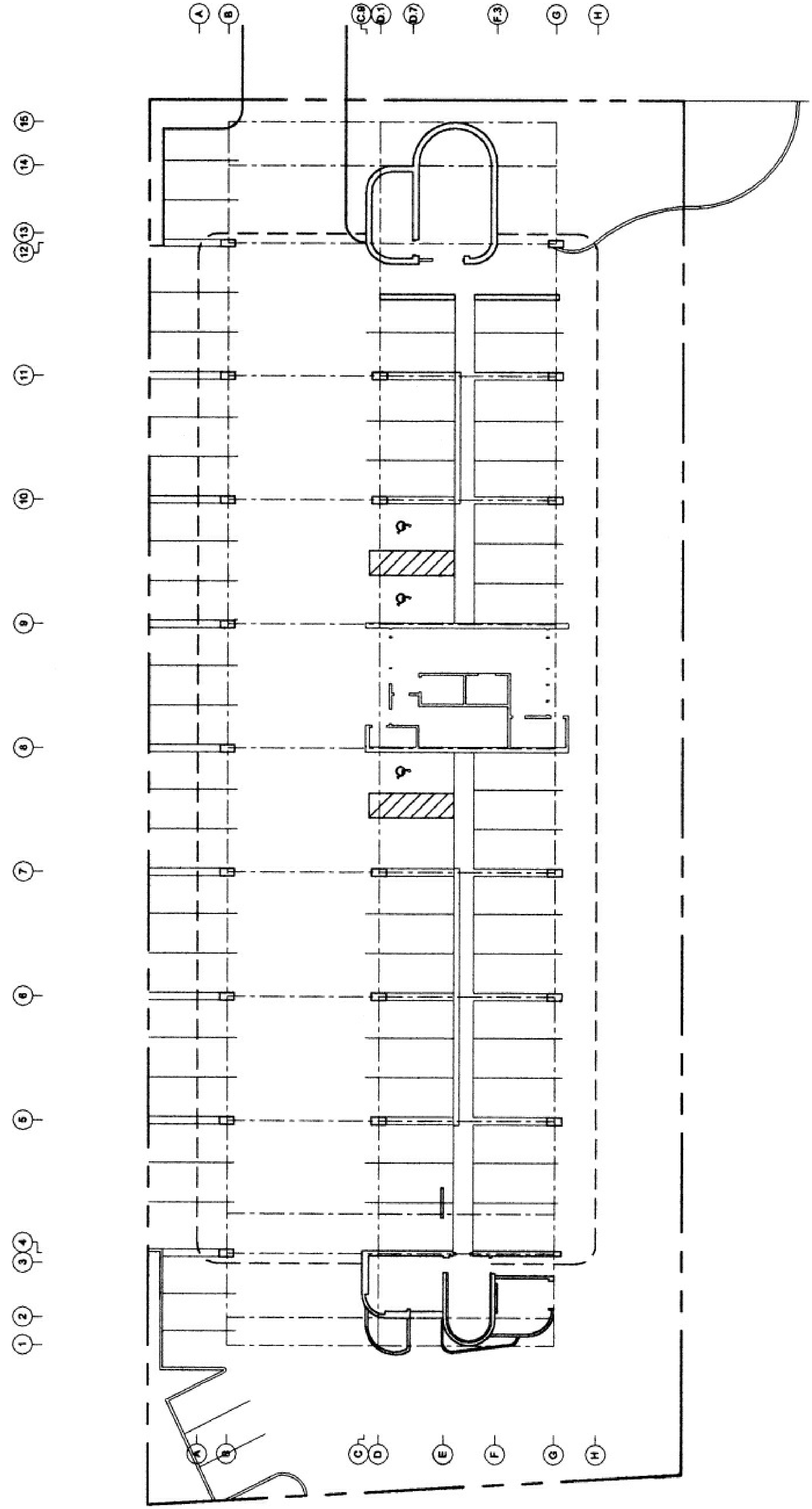

A
B
C.9
D.1
D.7
F.3
G
H
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
C
D
E
F

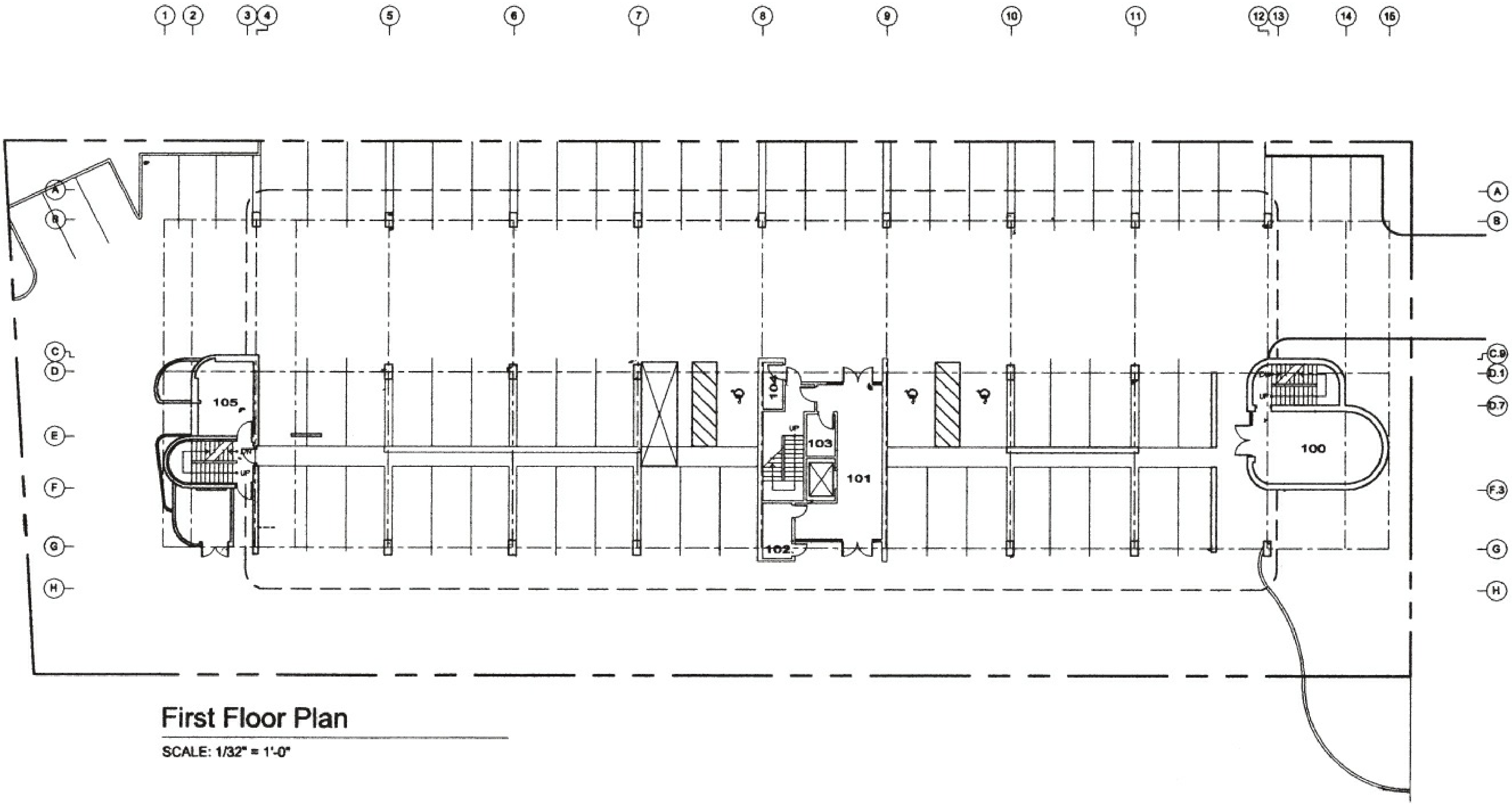
Figure 8.83 Madison Building—Stage III: Working drawing—ground…floor plan.

Stage IV

The drawing for Stage IV incorporated the required number of risers and treads for the stairs while establishing the elevator size. The CAD operator designated the doors and the glass areas that are adjacent to the lobbies, along with the room numbers, for the various areas. These room numbers were eventually defined for their use on a room schedule.

As mentioned earlier in regard to the schematic studies, the architect and the mechanical engineer decided to incorporate an “off…peak cooling system,” which can also be referred to as an “ice bank” system. This system requires a pool for the storage of the coolant. The pool is now shown at the matrix lines of D and E. The purpose for the off…peak cooling system is to save energy and costs by developing the coolant necessary for daily use.

The system produces coolant in the late night or early morning hours when the demand for and cost of electricity is at a minimum. Finally, the title and the scale were established for this drawing. Figure 8.84 depicts the first…floor plan for Stage IV.



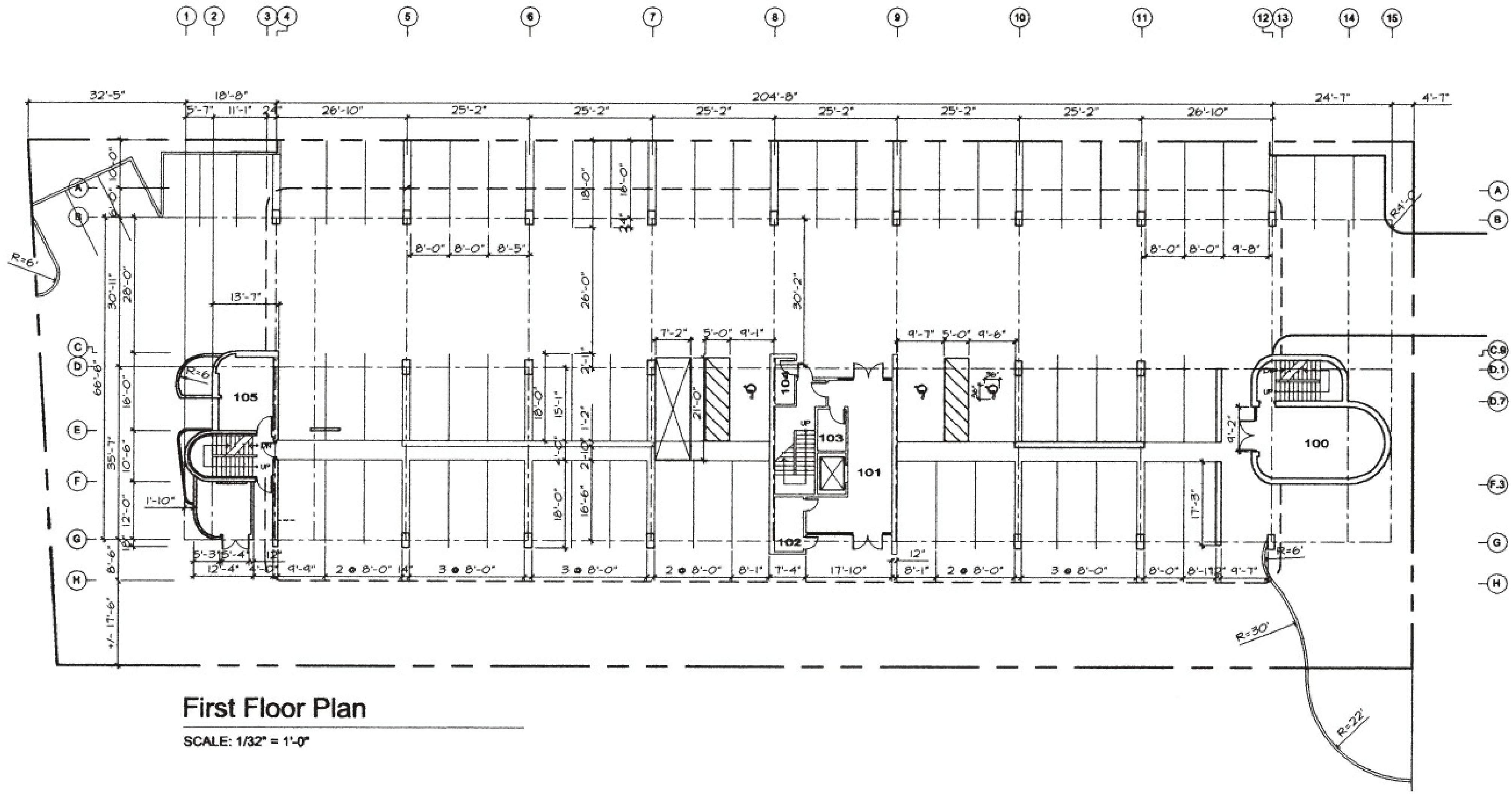
First Floor Plan

SCALE: 1/32" = 1'-0"

Figure 8.84 Madison Building—Stage IV: Working drawing—ground…floor plan.

Stage V

At Stage V, dimension lines and dimensions were established for the column and wall locations. These particular dimension lines related to the matrix system and provided a basis for the dimensioning of the various spaces. Parking stalls and automobile access areas were dimensioned, along with the handicapped parking access areas. The dimensioning of the walkways, trash areas, and the off…peak cooling pool were shown at this stage. The drawing also defined the various curb radius dimensions within the parking and automobile access areas. This drawing stage is shown in Figure 8.85.



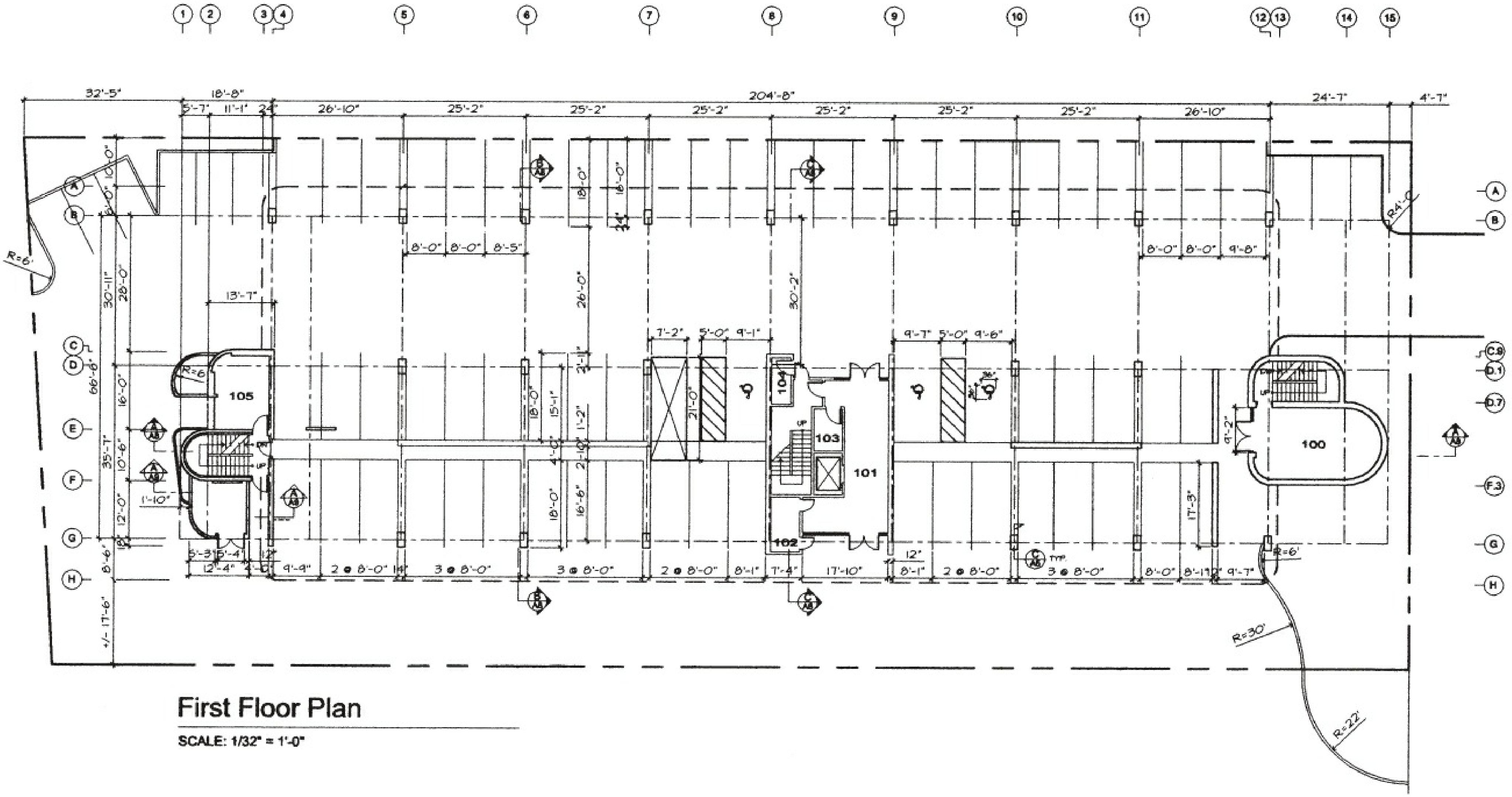
First Floor Plan

SCALE: 1/32" = 1'-0"

Figure 8.85 Madison Building—Stage V: Working drawing—ground…floor plan.

Stage VI

In Stage VI, the principal information added includes the various locations of the building structural sections. This is done at this time in order to allow the structural engineering firm to commence with the initial structural design and calculations. Note the bubble designations and the direction from which the building section will be viewed. This stage is illustrated in Figure 8.86.



First Floor Plan

SCALE: 1/32" = 1'-0"

Figure 8.86 Madison Building—Stage VI: Working drawing—ground‐floor plan.

Second‐Floor Plan Working Drawing Development

Stage I

The first task for Stage I of the second‐floor plan is to review and finalize the matrix symbolizing for all structural steel columns and exterior walls. This completed drawing is a culmination of a series of drawings evolving from the initial matrix that was shown in Figure 8.81. The finalized matrix drawing is depicted in Figure 8.87.

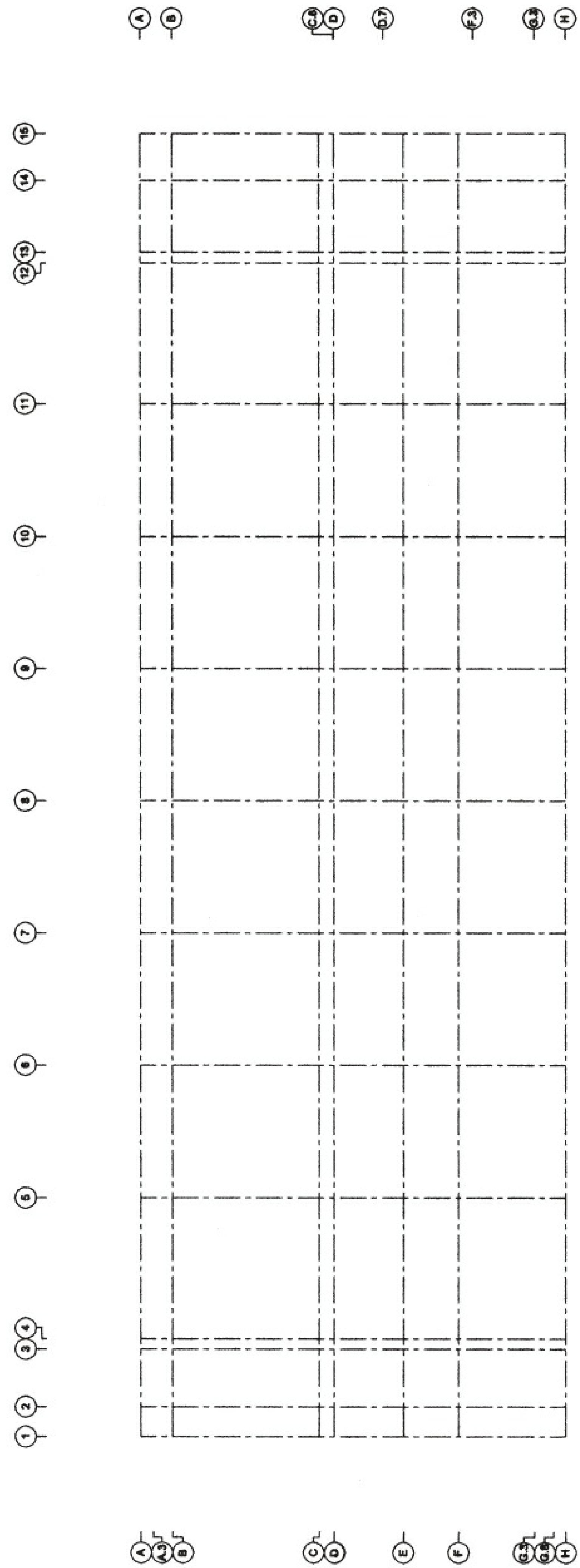
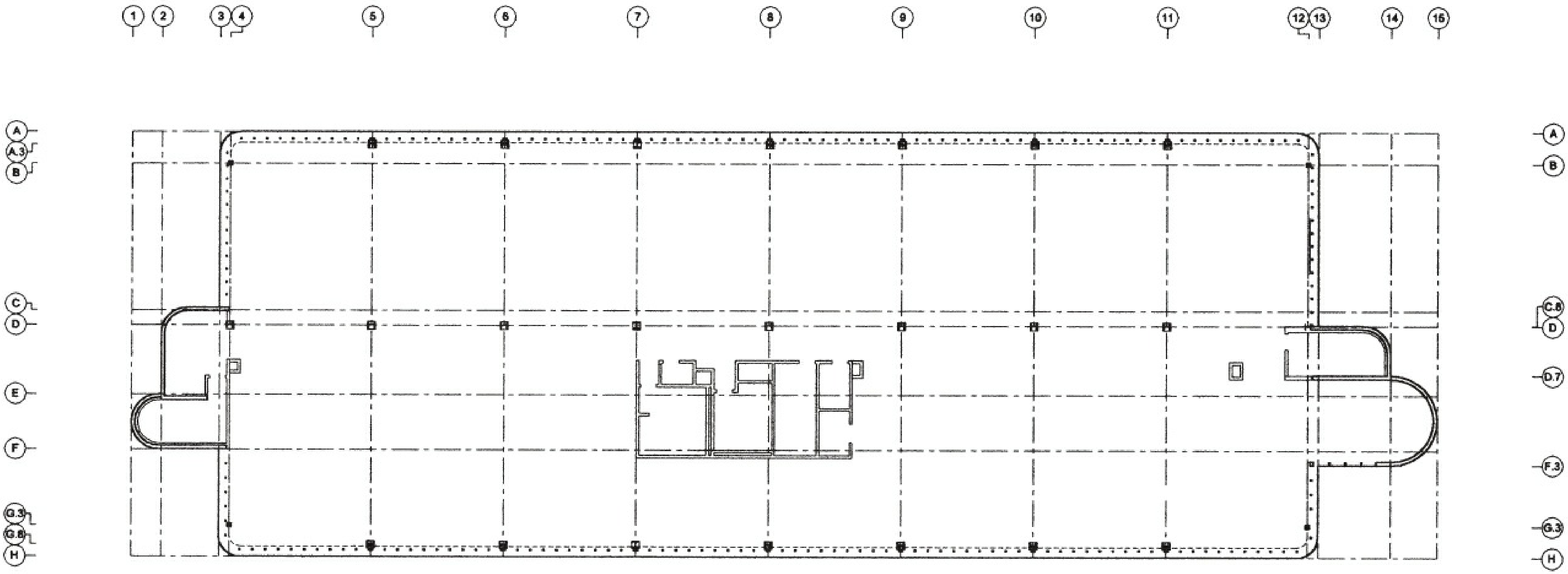

A
B
C.8
D
D.7
F.3
G.8
H
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
A
A.3
B
C
D
E
F
H

Figure 8.87 Madison Building—Stage I: Second…floor matrix.

Stage II

With the use of the finalized matrix developed in Stage I as a basis for identifying the locations of steel columns and walls, a floor plan is developed that is primarily an overlay of the finalized first…floor plan. This plan indicates the wall locations from the final first…floor plan, including the walls for the elevator shaft and stairwells and the exterior wall extremities. This stage also shows the locations for all the vertical window mullions around the perimeter of the exterior walls. The drawing for Stage II is illustrated in Figure 8.88.

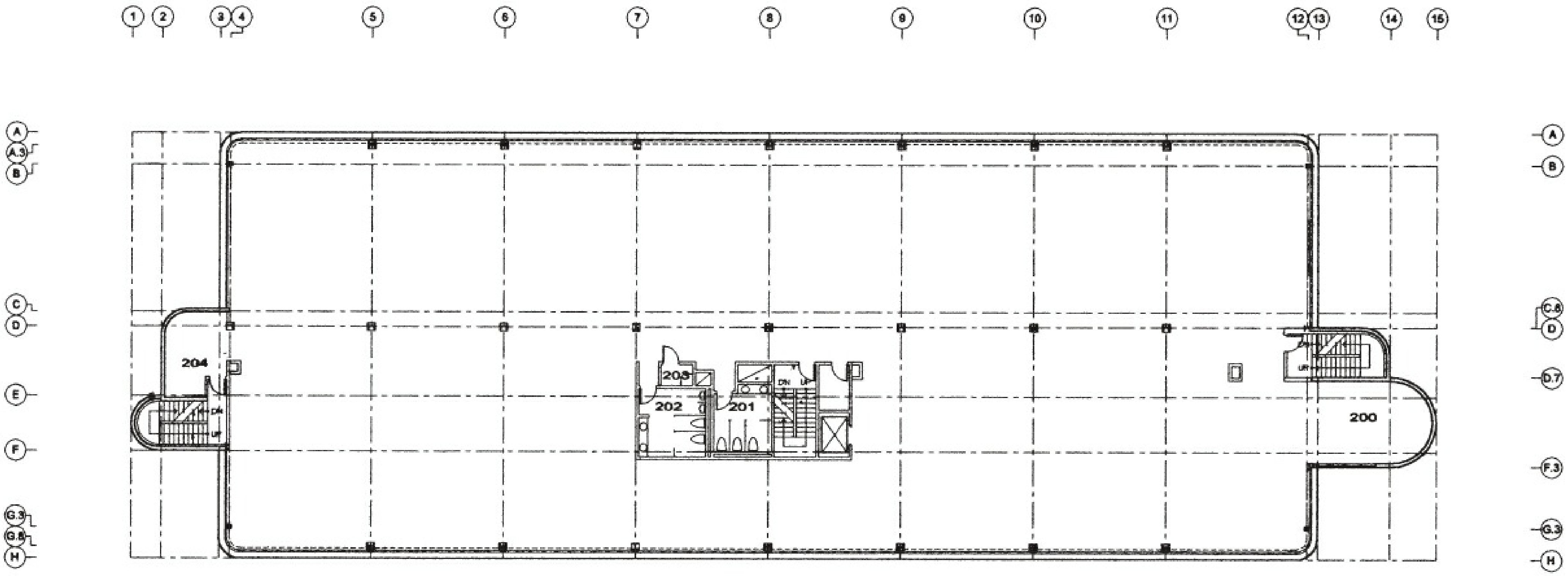


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
A
A.3
B
C
D
E
F
G.3
G.8
H
A
B
C.8
D
D.7
F.3
G.3
H

Figure 8.88 Madison Building—Stage II: Working drawing—second…floor plan.

Stage III

The purpose of Stage III for the second…floor plan is to delineate the risers and treads for all the stairwells, the elevator location, and the required vertical shafts for the housing of mechanical ducts. Restroom locations are also included in this stage. The room number designations are indicated, as well as door locations and the door swing directions. Finally, the second…floor plan title and drawing scale are shown graphically. This drawing is shown in Figure 8.89.

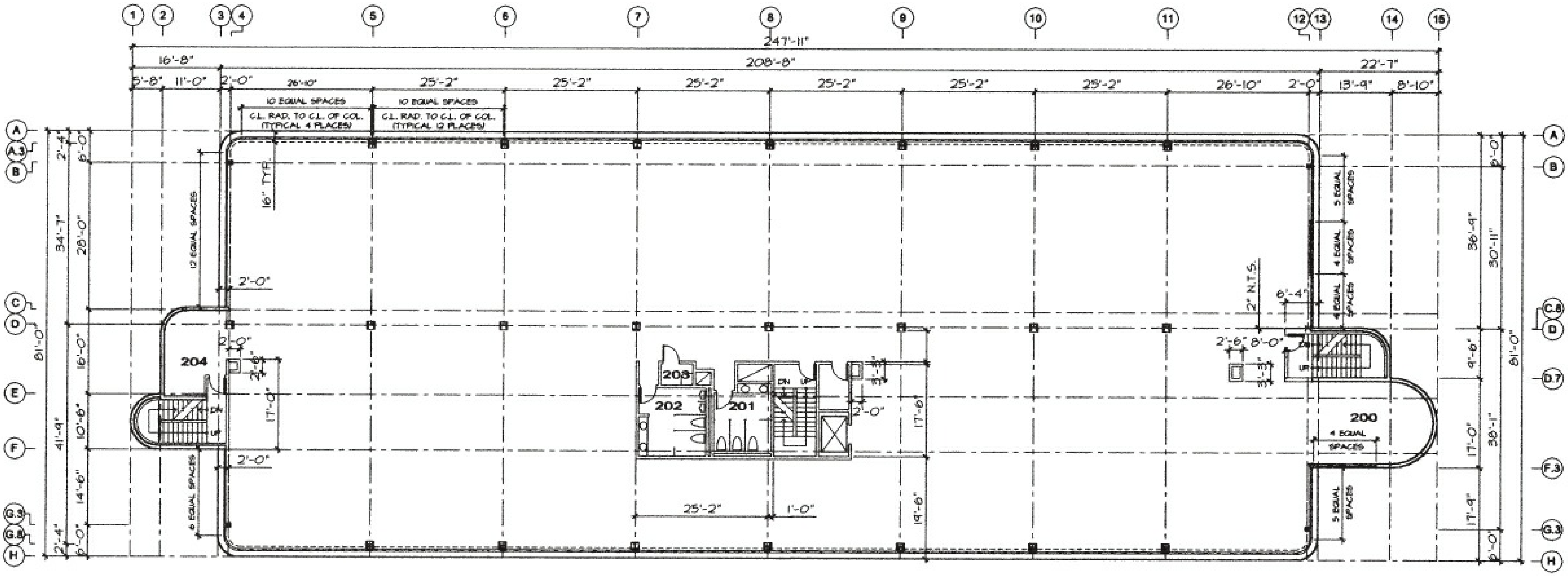


Second Floor Plan

Figure 8.89 Madison Building—Stage III: Working drawing—second…floor plan.

Stage IV

Stage IV of the second floor plan deals mainly with dimensioning and notes pertaining to the spacing of the vertical window mullions. The dimensioning values have been established primarily in the final stage of the first…floor plan, with the main supporting columns aligning with the floors above. In addition, the referencing matrix symbols are identical to those of the first…floor plan. This stage is depicted in Figure 8.90.

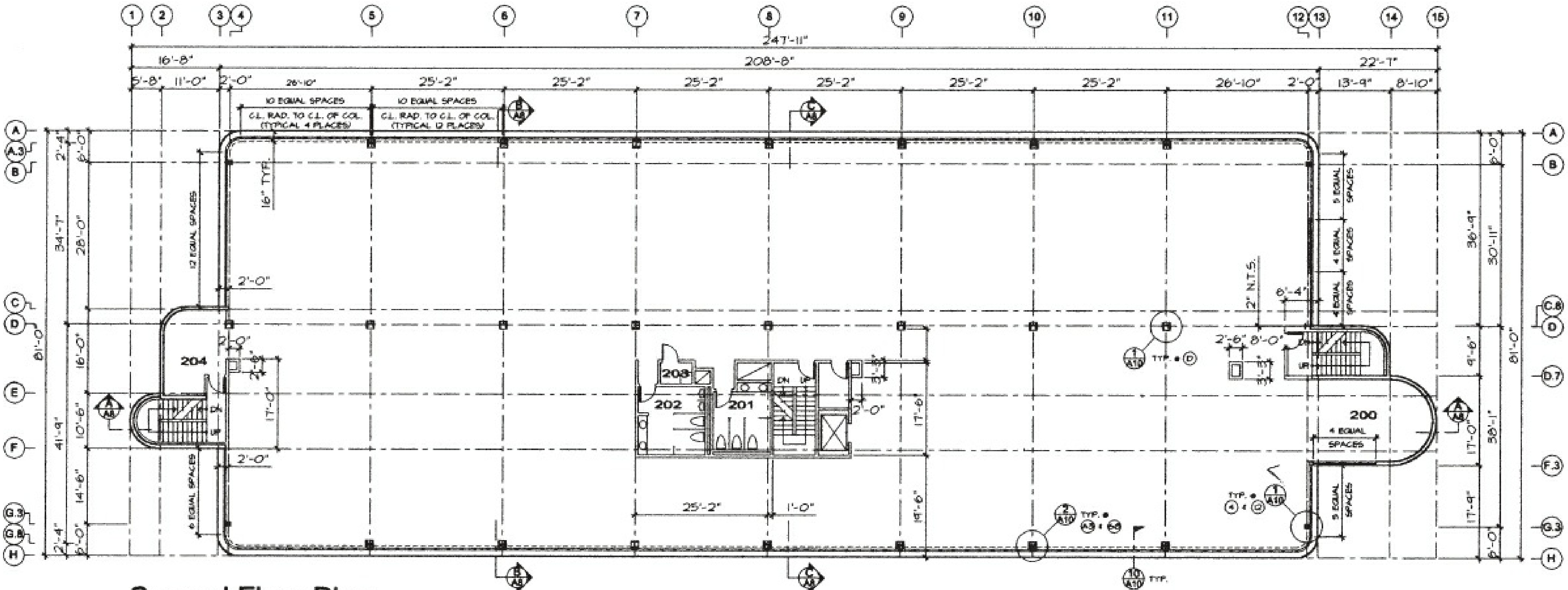


Second Floor Plan

Figure 8.90 Madison Building—Stage IV: Working drawing—second…floor plan.

Stage V

The next step in completing the second…floor plan is to designate the locations for the structural cross…sections and to provide a symbol for the referencing of these structural sections. These sections are taken in the north/south and east/west directions. Other details that are symbolized with a bubble and a detail reference are shown for a steel column and steel beam connection. These reference bubbles occur at the center supporting columns. Further detail symbols are indicated for the exterior window and wall assembly, while providing a reference detail symbol for the steel columns at the exterior walls. Notes for the exterior window mullion spaces are shown for the glazing areas found on the east/west walls and the north/south walls. The completion of Stage V is illustrated in Figure 8.91.



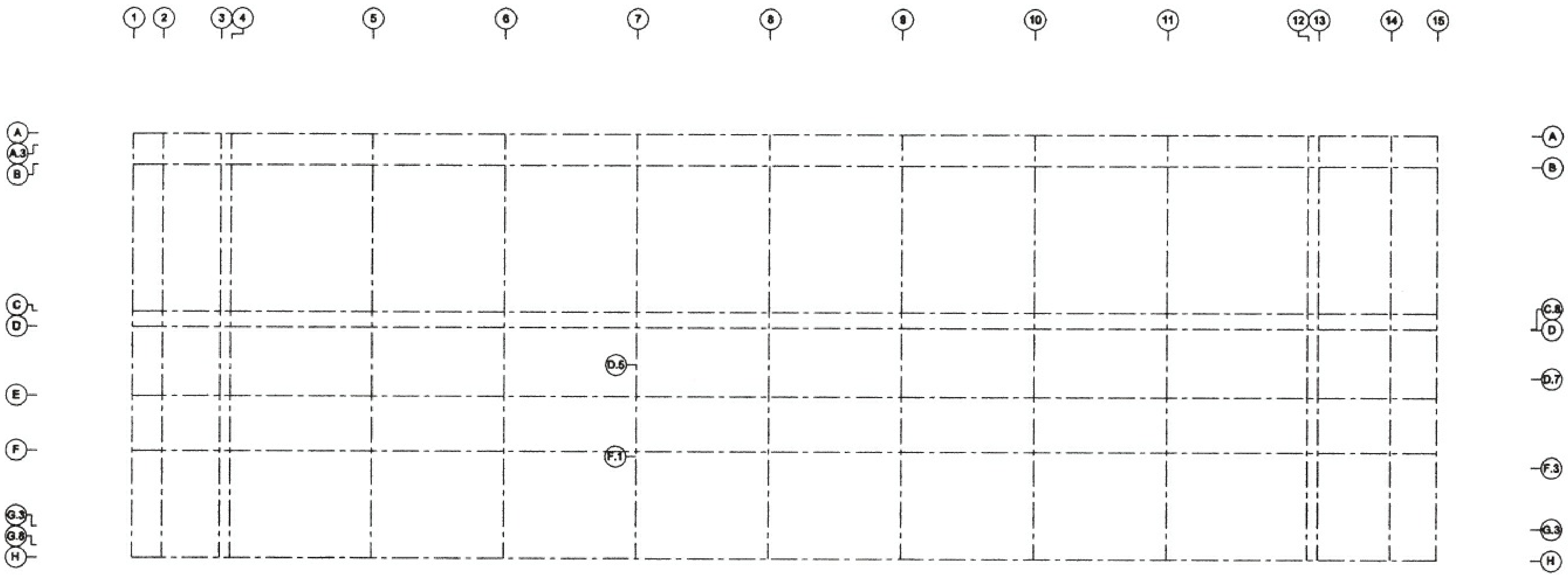
Second Floor Plan

Figure 8.91 Madison Building—Stage V: Working drawing—second‑floor plan.

Third‑Floor Plan Working Drawing Development

Stage I

The first step in Stage I for the development of the third‑floor plan is to start and work from the governing matrix system, as done for the second‑floor plan. The only difference between the matrix system for the second‑floor plan, as shown in Figure 8.87, and the matrix system for the third‑floor plan is the addition of two matrix symbols identified as D/5 and F/1, which are located at two interior walls. Figure 8.92 illustrates the matrix system that is used for the third‑floor plan.



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
A
A.3
B
C
D
E
F
G.3
G.8
H
D.5
F.1
A
B
C.8
D
D.7
F.3
G.3
H

Figure 8.92 Madison Building—Stage I: Third‐floor matrix.

Stage II

Stage II for the third‐floor plan is a duplicate of the CAD drawing used in Stage II for the second‐floor plan. The only variation from the second‐floor plan drawing is the addition of matrix symbols D/5 and F/1, as indicated in Figure 8.93. The locations of the vertical window mullions, corresponding to the second‐floor glazing, are also shown at this stage.

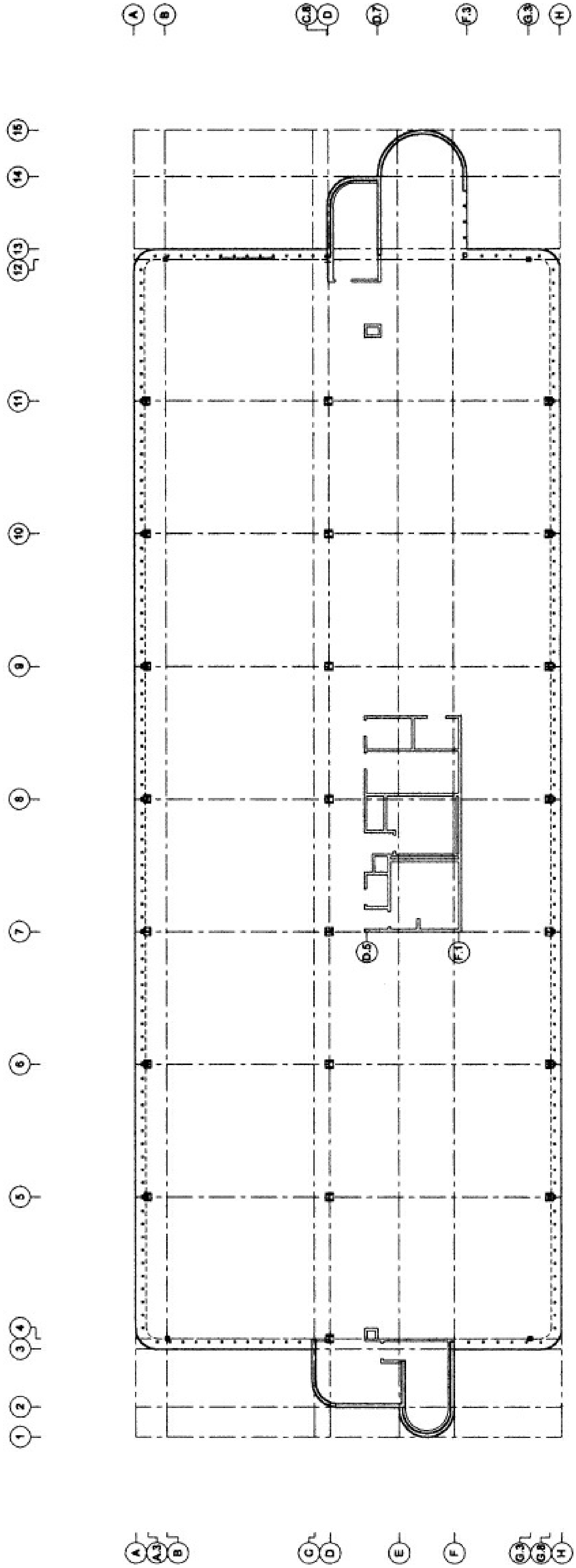
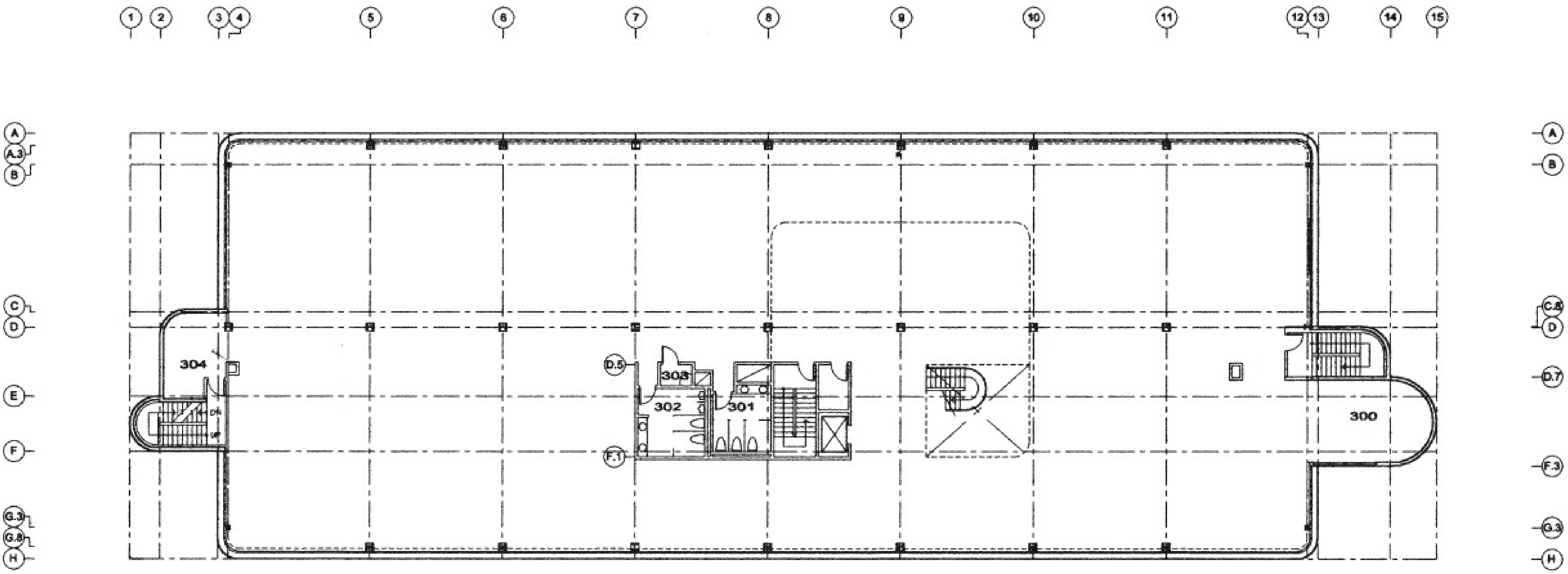

A
B
C.8
D
D.7
F.3
G.3
H
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
D.5
F.1
A.3
C
E
F
G.8

Figure 8.93 Madison Building—Stage II: Working drawing—third…floor plan.

Stage III

Stage III shows the risers and treads for all the stairwells, which include an additional stair for access to a mezzanine level. The mezzanine level will be accessible only from the third floor. Broken lines are added to this drawing to depict the mezzanine floor area above. Also incorporated at this stage are the men's and women's restrooms, the elevator, the vertical mechanical shafts required for the air…conditioning ducts, and the room numbering for the various areas. The title identifying the third…floor plan and the scale of the drawing are added at this stage as well. Figure 8.94 illustrates Stage 3 of the third…floor plan.

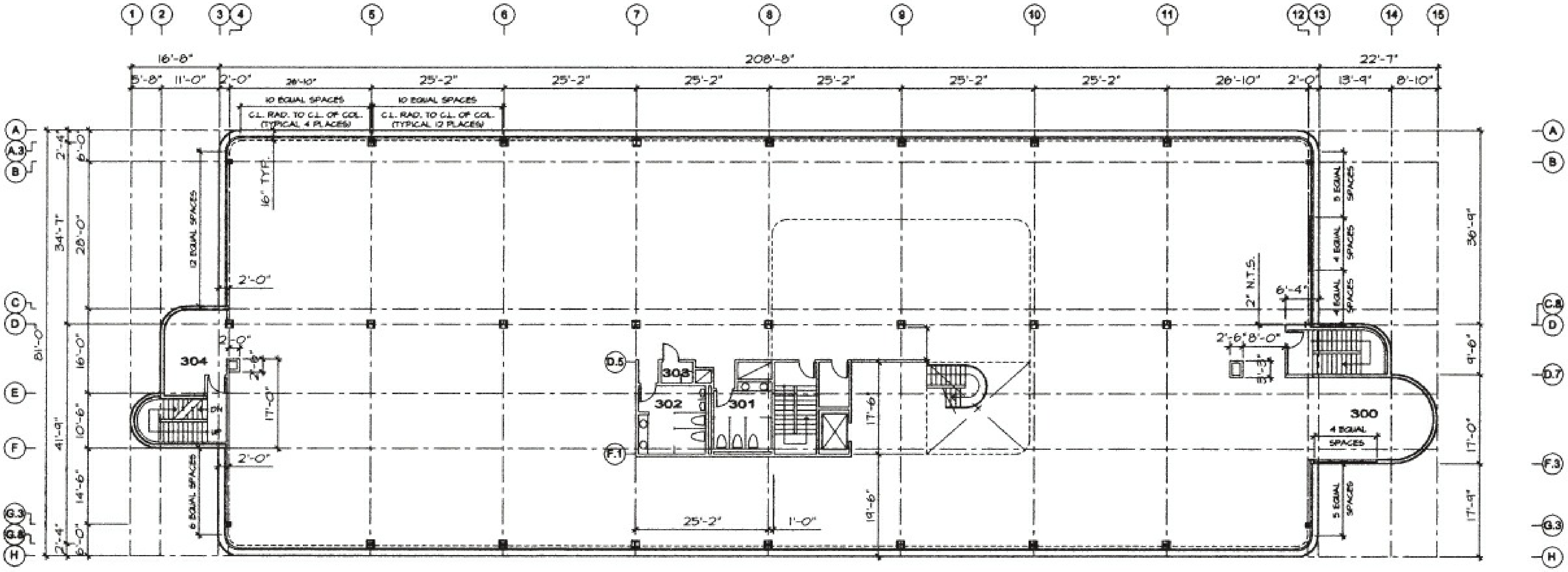


Third Floor Plan

Figure 8.94 Madison Building—Stage III: Working drawing—third…floor plan.

Stage IV

The initial step for Stage IV is to lay out all the necessary dimension lines for all sides of the structure and the numerical values within the dimension lines. The drawing for Stage 4 of the third…floor plan is depicted in Figure 8.95.

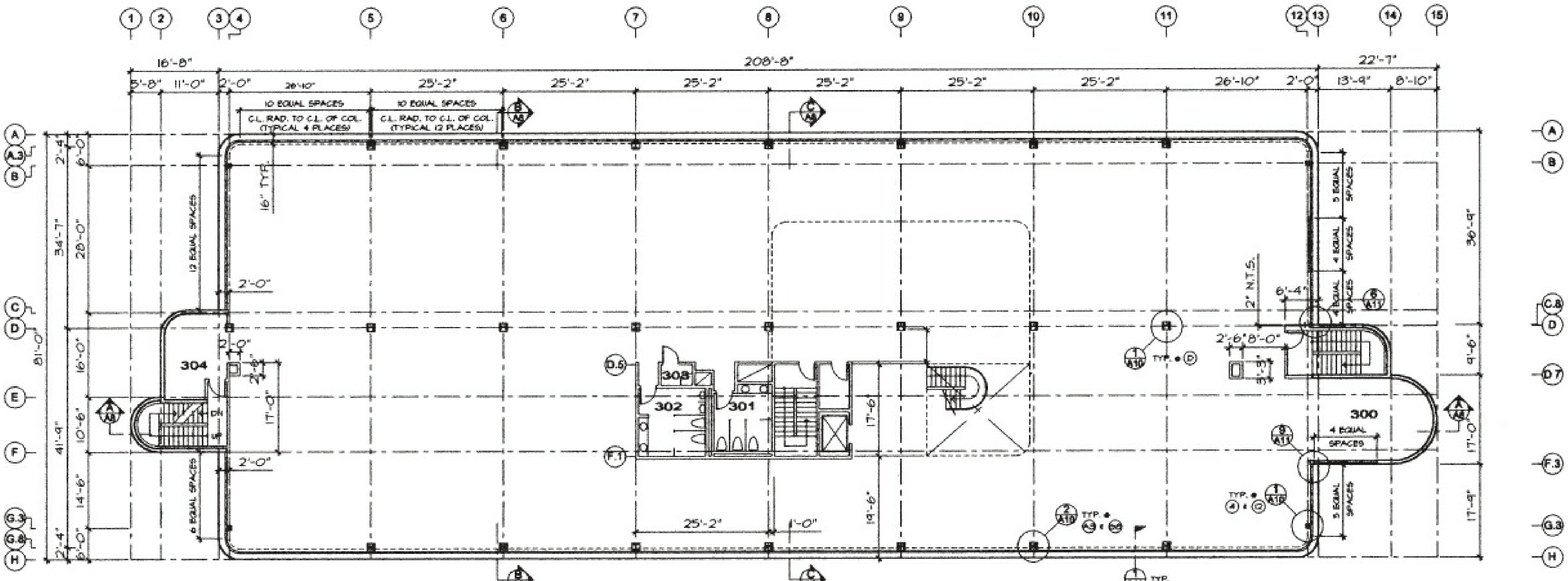


Third Floor Plan

Figure 8.95 Madison Building—Stage IV: Working drawing—third‐floor plan.

Stage V

The main difference between Stage V and the previous stage is the addition of various detail reference symbols. These symbols illustrate where the building cross‐sections are to be taken and the viewing direction. Detail bubbles indicating the detail number and sheet number are also shown. These particular bubbles are located at the steel column and steel beam connection in the center of the building and at the exterior walls. Figure 8.96 illustrates the drawing for Stage V.



Third Floor Plan

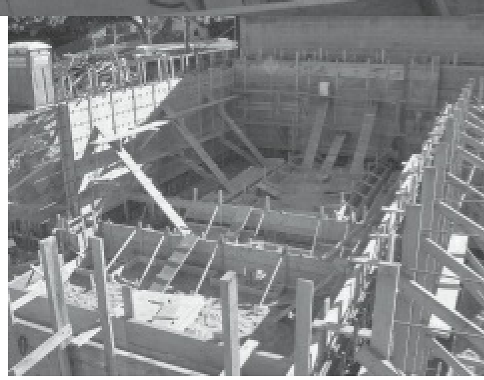
Figure 8.96 Madison Building—Stage V: Working drawing—third…floor plan.

Key Terms

- face of stud (F.O.S.)
- break line
- checklist
- electrical rating
- exterior hinged door
- finished opening
- flush outlet
- grid
- interior hinged door
- offset
- pilasters
- planted
- poché
- reference bubble
- rough opening
- routing schedule
- specifications
- steel frame
- steel stud

Chapter 9

FOUNDATION AND ROOF PLANS, FLOOR, AND ROOF FRAMING SYSTEMS



INTRODUCTION

This is a very unique chapter as compared to the others. Five distinctly different topics will be covered: foundation types and their evolution into working drawings, followed by roofs and how to configure the complicated geometric shapes that will intersect each other to integrate the forms, while including the removal of rain water. The next two topics describe various materials and framing systems and the implications for working drawings. The final topic will demonstrate the procedures and steps used to work with the foundation and roof. They will be taken from the case studies found in Section III.

Foundation Defined

A foundation plan is a drawing that shows the location of all concrete footings, concrete piers, and structural underpinning members required to support a structure. The main purpose of all the foundation footings is to distribute the weight of the structure over the soil.

TYPES OF FOUNDATIONS

Foundation Selection

While there are many types of foundation systems, two primary types of floor systems are used in foundation plans. These floor systems are constructed of concrete or wood or a combination of both. Each floor system requires a foundation to support the floor system and the structure.

As with all working drawings, standards must be established from office standards, if you are presently employed foundations are determined based on things like water line or the

level at which the moisture will not affect the structure, and the frost line, the level at which freezing temperatures will not affect the building.

Concrete Slab Floor: Foundation Plans

If you have selected concrete as the floor material for a specific project, first investigate the types of **foundation footing details** required to support the structure before drawing the foundation plan. The **footing design** will be influenced by many factors, such as the vertical loads or weight it is to support, regional differences, allowable soil… bearing values, established frost…line location, and recommendations from a soils and geological report for reinforcing requirements. Figure 9.1 illustrates a concrete footing and concrete floor with various factors influencing design.

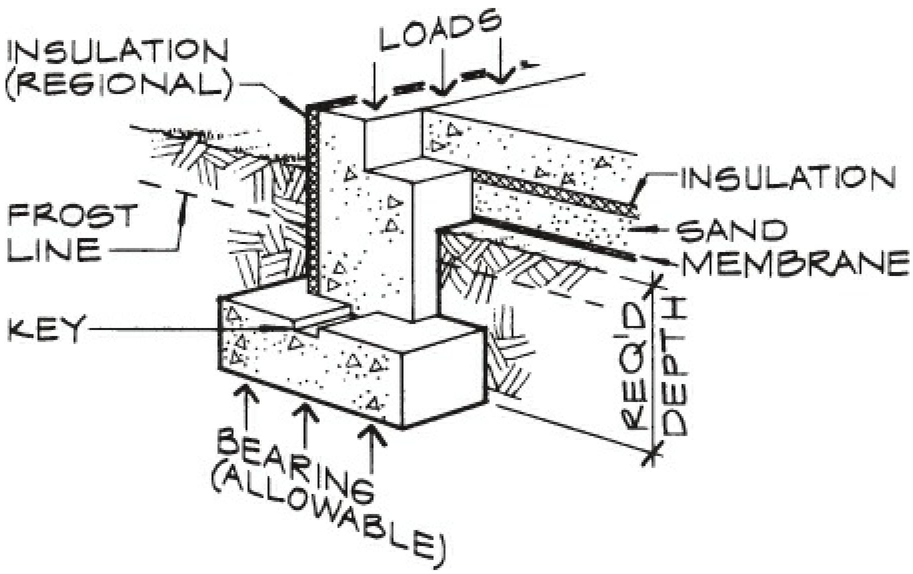
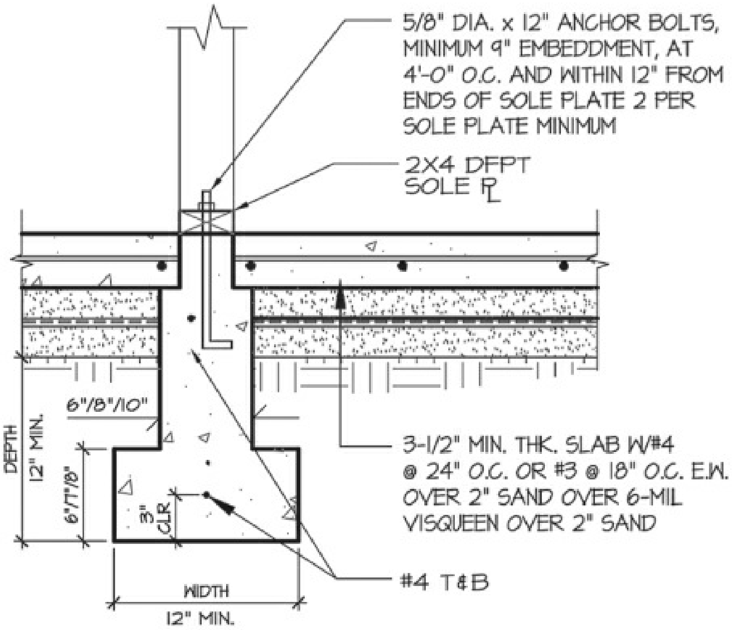
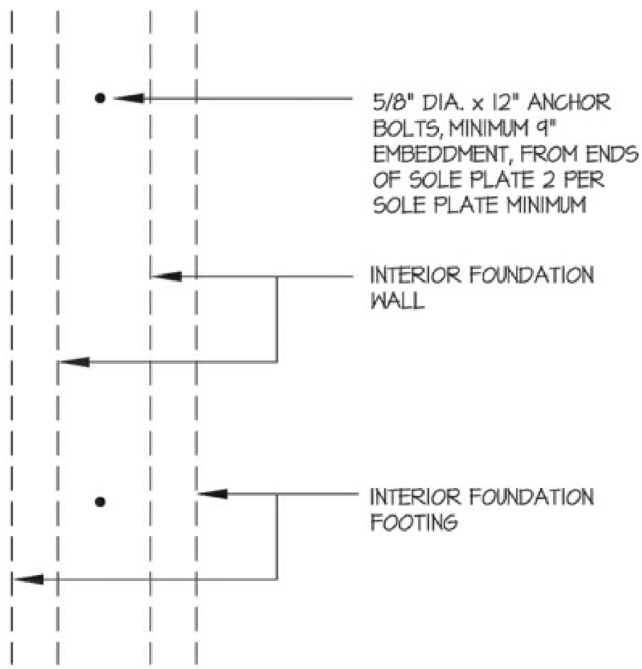


Figure 9.1 Concrete footing and floor with various influencing design factors.

A broken line represents the footing and foundation wall, located under the concrete slab or grade. This broken line is referred to as a **hidden line**. The solid line shows the edge of the concrete floor slab as projected above the grade level. Broken lines are mainly used to show footing sizes, configurations, and their locations below grade level or below a concrete floor; solid lines show those above. See Figure 9.2.



5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, AT 4'-0" O.C. AND WITHIN 12" FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM
2X4 DFPT SOLE PL
6"/8"/10"
DEPTH 12" MIN.
6"/7"/8"
3" CLR
3-1/2" MIN. THK. SLAB W/#4 @ 24" O.C. OR #3 @ 18" O.C. E.W. OVER 2" SAND OVER 6-MIL VISQUEEN OVER 2" SAND
#4 T&B
WIDTH 12" MIN.



5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM
INTERIOR FOUNDATION WALL
INTERIOR FOUNDATION FOOTING

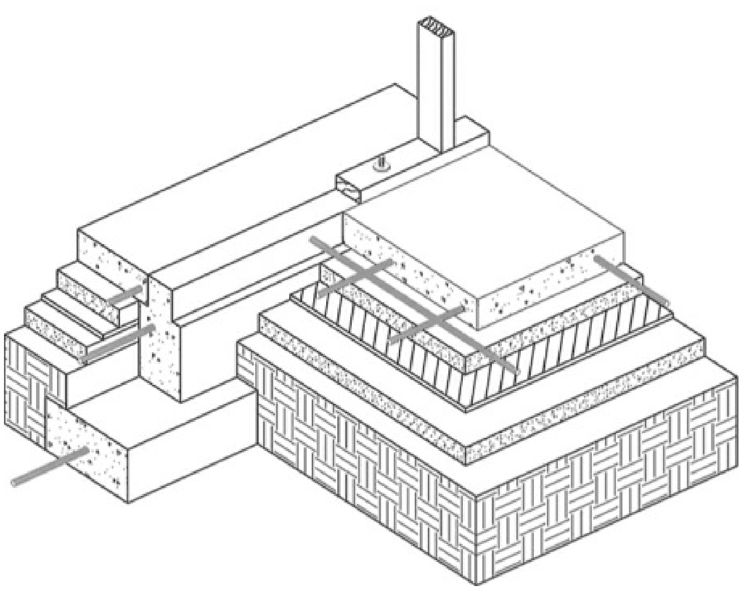
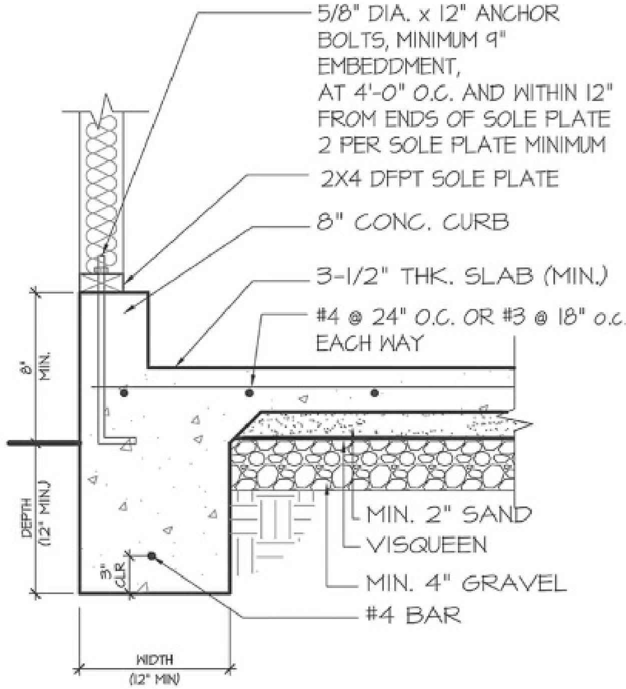
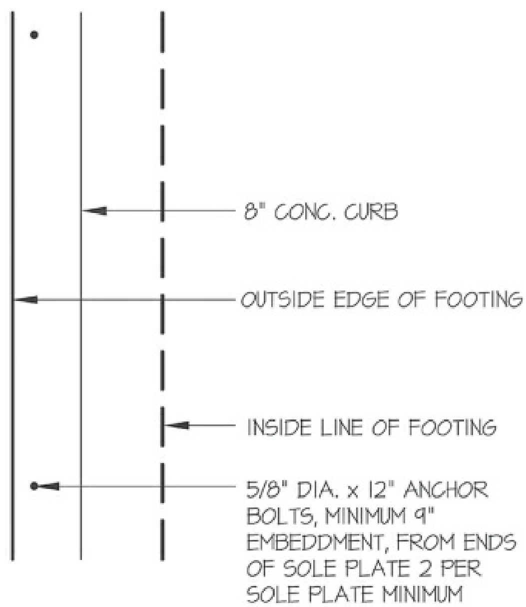


Figure 9.2 Detail of interior bearing footing.

An interior bearing footing might look like Figure 9.2. If it does, draw the plan view of this detail only with broken lines because all the configurations are under the concrete slab floor and grade.

Often, concrete curbs above the concrete floor levels are used to keep the garage floor within a few inches above the driveway while keeping the wood 8 inches or more from the ground. Curbs are ideal in areas where wood studs must be kept free of floor moisture. See Figure 9.3.


5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, AT 4'-0" O.C. AND WITHIN 12" FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM
2X4 DFPT SOLE PLATE
8" CONC. CURB
3-1/2" THK. SLAB (MIN.)
#4 @ 24" O.C. OR #3 @ 18" o.c. EACH WAY
8" MIN.
DEPTH (12" MIN.)
3" CLR
MIN. 2" SAND
VISQUEEN
MIN. 4" GRAVEL
#4 BAR
WIDTH (12" MIN)


8" CONC. CURB
OUTSIDE EDGE OF FOOTING
INSIDE LINE OF FOOTING
5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM

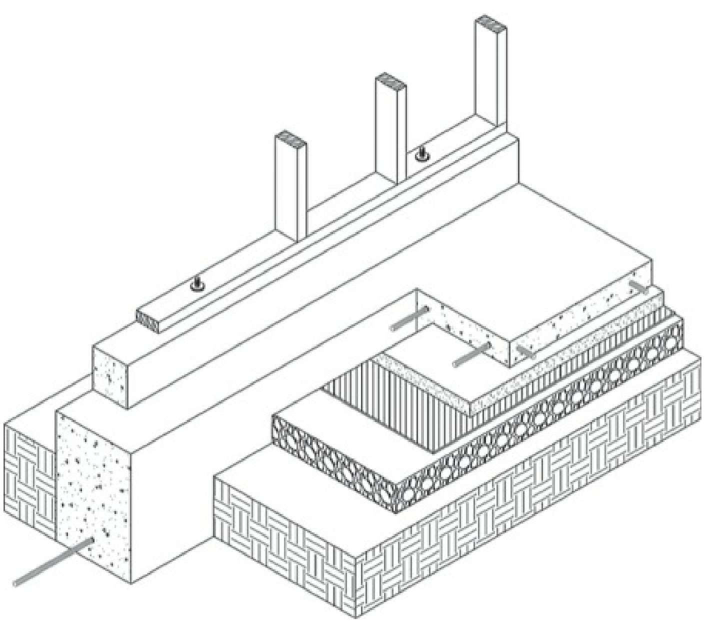
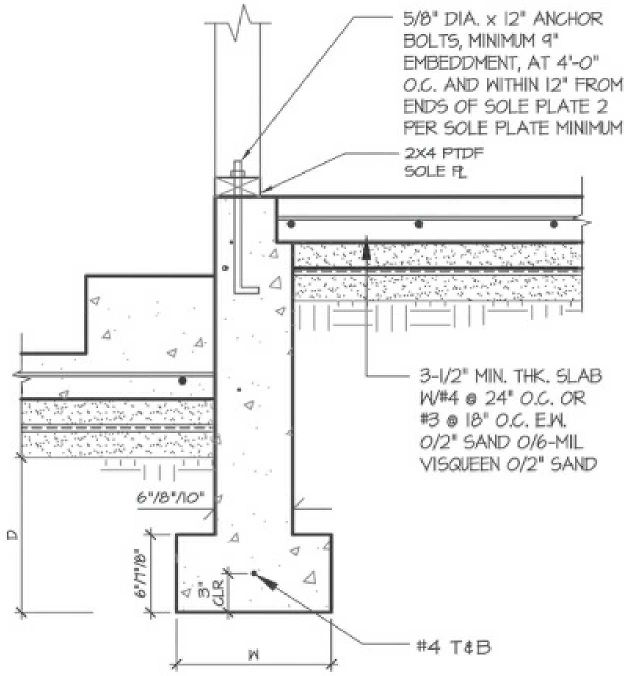
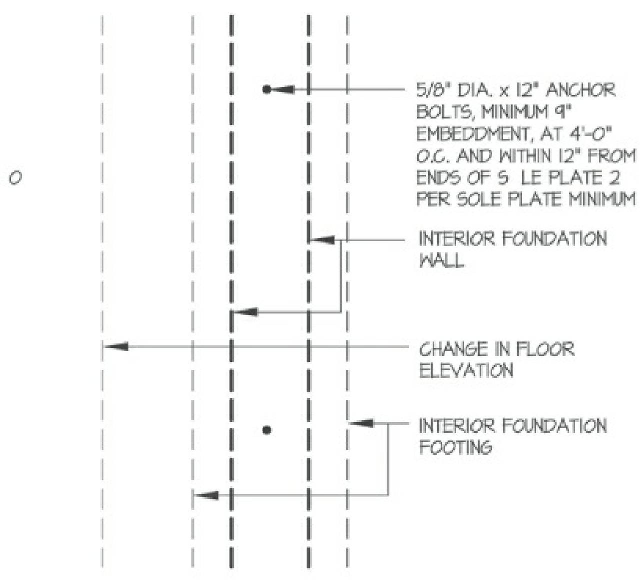


Figure 9.3 Exterior bearing footing with raised curb.

When you are faced with drawing concrete steps and a change of floor level, you may draw a plan view reflecting this section. See Figure 9.4.


5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, AT 4'-0" O.C. AND WITHIN 12" FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM
2X4 PTDF SOLE PL
3-1/2" MIN. THK. SLAB W/#4 @ 24" O.C. OR #3 @ 18" O.C. E.W. O/2" SAND O/6-MIL VISQUEEN O/2" SAND
6"/8"/10"
D
6"/7"/8"
3" CLR
#4 T&B
W


5/8" DIA. x 12" ANCHOR BOLTS, MINIMUM 9" EMBEDDMENT, AT 4'-0" O.C. AND WITHIN 12" FROM ENDS OF S LE PLATE 2 PER SOLE PLATE MINIMUM
INTERIOR FOUNDATION WALL
CHANGE IN FLOOR ELEVATION
INTERIOR FOUNDATION FOOTING

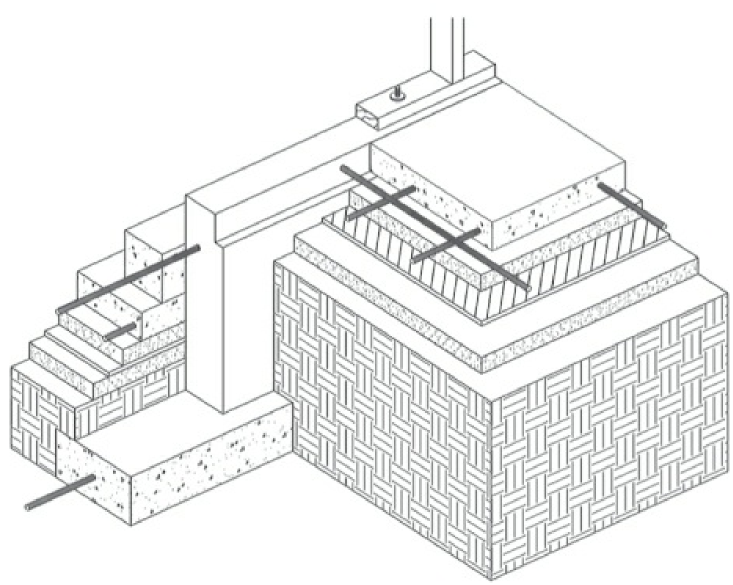


Figure 9.4 Interior bearing footing.

To aid in visualization of the foundation of the structure and its various components, a three‐dimensional (3‐D) image was produced. Two major segments were enlarged to help readers visualize the interior shapes and connections. One can actually see the exterior bearing footing and the change in level in Figure 9.5.

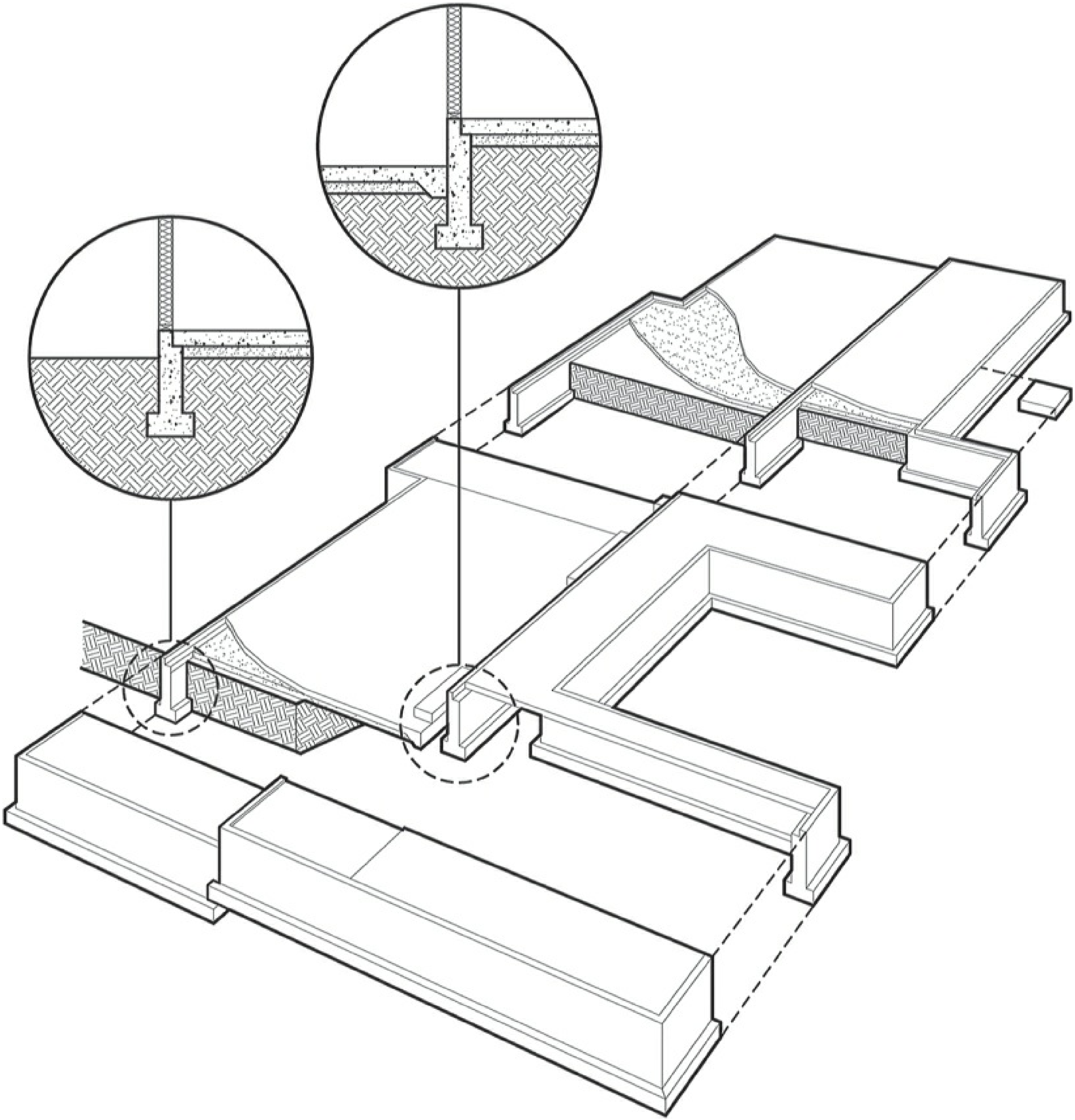


Figure 9.5 3‐D foundation image.

Drawing the Foundation Plan

Lay your tracing or create a new drawing layer over the floor‐plan drawing, then draw the configuration of the floor plan, as well as the internal walls, columns, fireplaces, and so on, that require foundation sections. After this light tracing, you are ready to finalize the drafting.

The final drafting is a graphic culmination, in plan view, of all the foundation walls and footings. Start with all the interior bearing and non‐bearing foundation conditions. Represent these with a dotted line according to the particular sections in plan view. Figure 9.6 shows an example of a foundation plan for a residence, incorporating the plan views similar to Figures 9.2 through 9.5, as previously discussed.

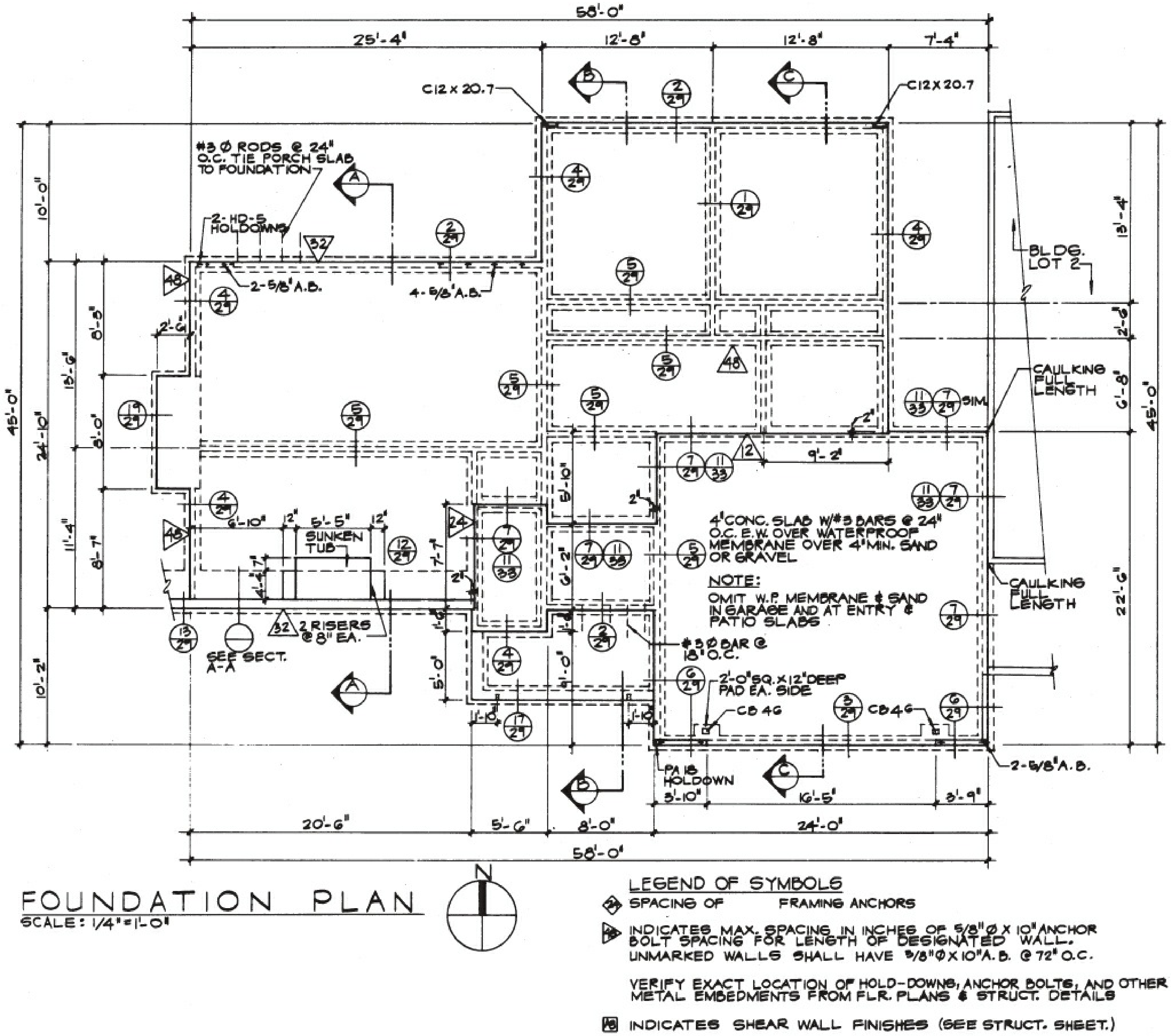


Figure 9.6 Foundation plan for a concrete floor.

Usually, various notes are required for items to be installed before the concrete is poured. An item like a **post hold‐down** or column base (a U‐shaped steel strap for bolting to a post and embedded in concrete so as to resist lateral forces; see Figure 9.7) should be shown on the foundation plan, because its installation is important in this particular construction phase. Note the *call‐out* (identification reference system) for this item in Figure 9.6.

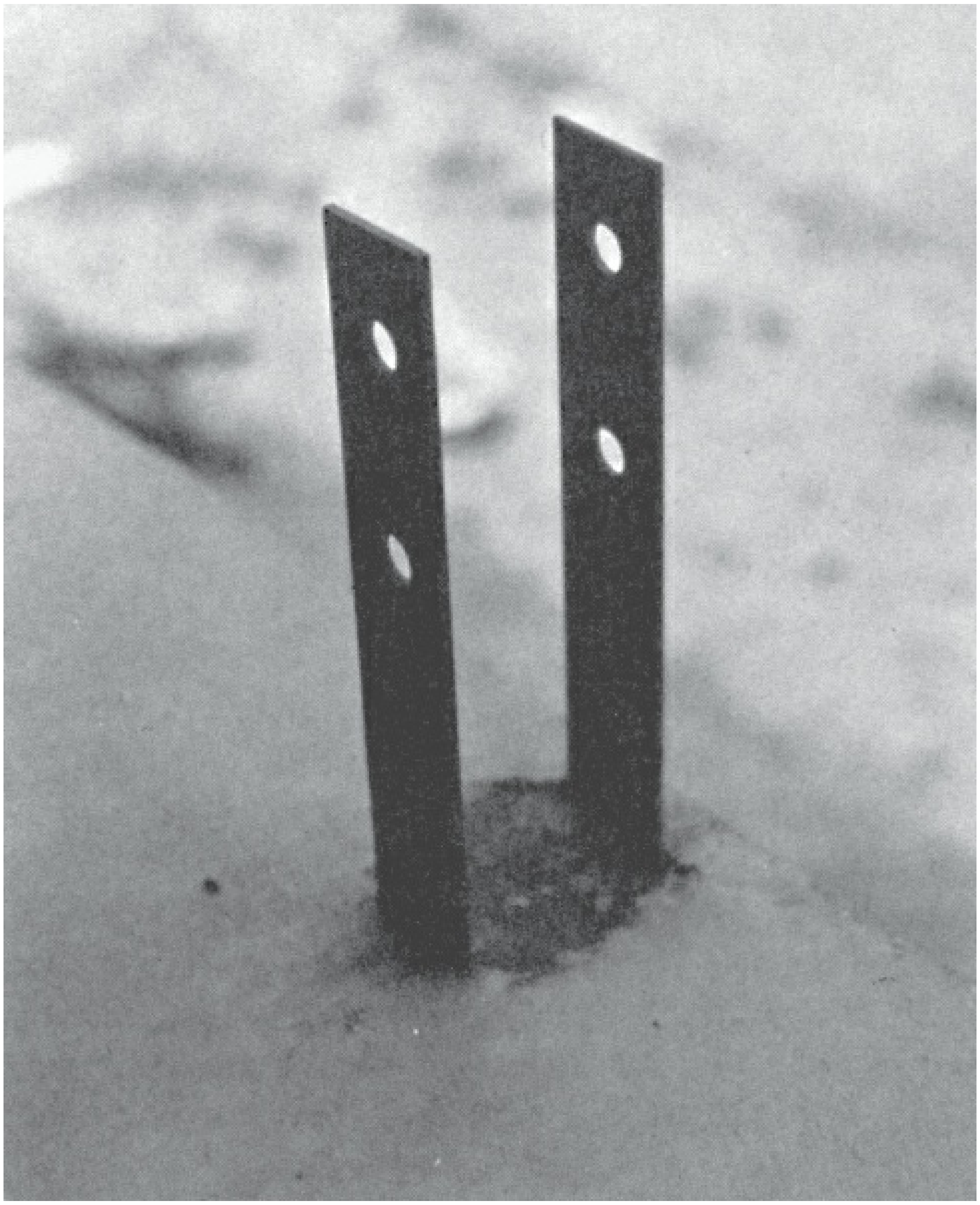


Figure 9.7 Post hold‐down at the base of a column.

Drawing Fireplaces. A drawing of a masonry fireplace on the foundation plan should have the supporting walls crosshatched. (To **crosshatch** is to shade with crossed lines, either diagonal or rectangular.) Show the fireplace footing with a broken line. When numerous vertical reinforcing bars are required for the fireplace, it is necessary to show their size and location, because they are embedded in the fireplace.

Strengthening Floors. Requirements for strengthening concrete floors with reinforcing vary by project, so it is important to show their size and spacing on the foundation plan. The foundation plan in Figure 9.6 calls for a 6 × 6 × 10 × 10 welded wire

reinforcing mesh to strengthen the concrete floor. This call…out tells us that the mesh is in 6″ × 6″ squares and made of number 10 gauge wire in both directions. Figure 9.8 shows how the reinforcing mesh and a plastic membrane are placed before the concrete is poured. Deformed reinforcing bars are also installed to strengthen the concrete slab floors. The size and spacing of these bars are determined by factors such as excessive weights expected to be carried by the floor and unfavorable soil conditions.

Figure 9.8 Reinforcing mesh and plastic.

Sloping Concrete Areas. When concrete areas have to be sloped for drainage, indicate this on the foundation plan. You can do this with a directional arrow, noting the number of inches or 1% slope for the concrete. See Figure 9.6, in which a garage slab is sloped to a

door.

Your foundation plan dimensioning should use the identical dimension…line locations of the floor plan. For example, centerline dimensions for walls above should match centerline dimensions for foundation walls below. This makes the floor and foundation plans consistent. When you lay out dimension lines, such as perimeter lines, leave space between the exterior wall and first dimension line for foundation section symbols. As Figure 9.6 shows, you must provide dimensions for every foundation condition and configuration. Remember, the people in the field do not use measuring devices; rather, they rely on all the dimensions you have provided on the plan.

In some cases, the foundation dimensioning process may require you to make adjustments for stud wall alignments. For example, if studs and interior finish must be aligned, be sure to dimension for foundation offset correctly to achieve the stud alignment. See Figure 9.9. In this figure, the 3½″ stud, the foundation wall, and the footing of the exterior wall are not aligned with the interior foundation wall and footing.

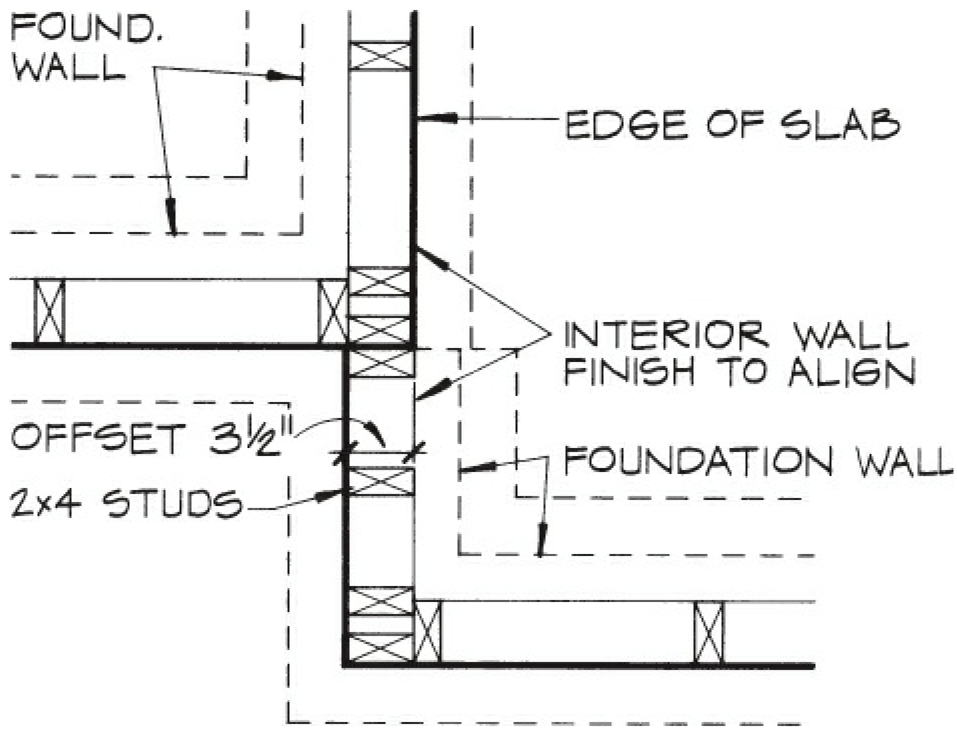


Figure 9.9 Stud wall alignment.

Provide reference symbols for foundation details for all conditions. Provide as many symbols as you need to remove any guesswork for the contractors in the field. As Figure 9.6 shows, the reference symbol will have enough space within the circle for letters and/or numbers for detail and sheet referencing.

Foundation Details for Concrete Slab Floor

For most cases, foundation details are drawn using an architectural scale of ¾″ = 1′…0″, 1″ = 1′…0″, 1½″ = 1′…0″, or 3″ = 1′…0″.

Scale selection may be dictated by office procedure or the complexity of a specific project. The more complex a detail is, the larger the scale you will require to provide the

additional information.

Different geographic regions may necessitate variations in footing depth, size, and reinforcing requirements. Check the specific requirements for your region to determine all of the variables required.

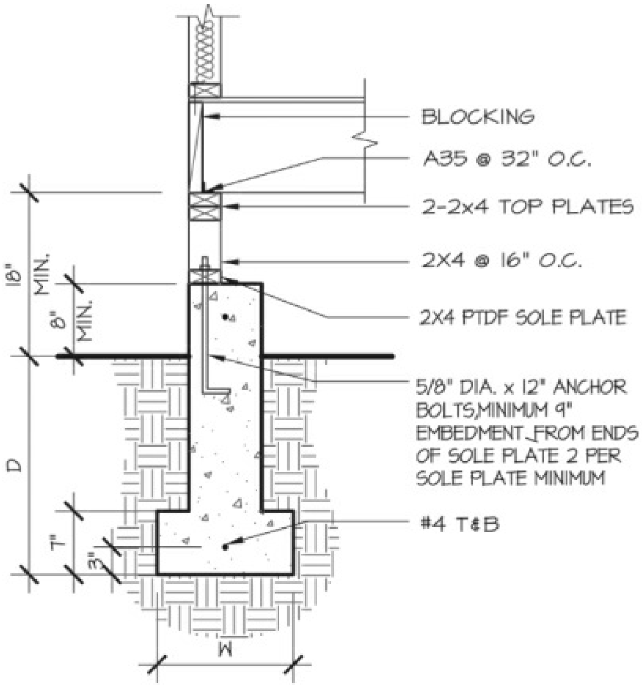
Foundation details for the residence shown in Figure 9.26 are drawn to incorporate a **two_pour system**; that is, the foundation wall and footing are poured first and the concrete floor later. Figure 9.26 shows the exterior bearing footing drawn in final form. In colder regions, the joint between the foundation wall and concrete floor slab is filled with insulation. In severe climates, one could also insulate the underside of the entire slab or even the footings themselves.

The interior bearing footing detail should also be drawn to reflect a two…pour system with call…outs for all the components in the assembly.

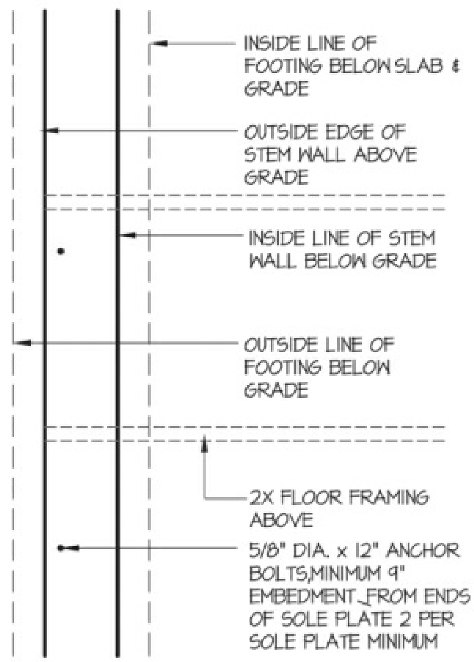
Powder…actuated nails, or **shot_ins**, as they are often called, can be used to replace the bolt in some municipalities. Because the nails are only a few inches long, a footing may not be required. However, they should be used only on non…bearing walls in the interior of a structure. These can often be found in tenant improvement projects where non…bearing partition walls are used for space layout. Shot…ins are not used for exterior or bearing walls because under stress the connection will fail.

Wood Floor: Foundation Plans

Prepare a foundation plan for a wood floor the same way you do for a concrete slab floor. First, determine the different footing types required to support the structure. Include in the design the footing width, stem wall dimensions, and the depth below grade. Show earth…to…wood clearances, sizes and treatment of wood members, floor sheathing, and the exterior wall and its assembly of components above the sheathing or subfloor level. See Figure 9.10. Interior bearing footing requirements can be done the same way, as they are very similar to the exterior footing system. In the plan view, the interior bearing footing will look similar to the exterior bearing footing in Figure 9.10.



BLOCKING
A35 @ 32" O.C.
2-2x4 TOP PLATES
2X4 @ 16" O.C.
2X4 PTDF SOLE PLATE
5/8" DIA. x 12" ANCHOR BOLTS,MINIMUM 9" EMBEDMENT FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM
#4 T&B
18" MIN.
8" MIN.
D
7"
3"
W



INSIDE LINE OF FOOTING BELOW SLAB & GRADE
OUTSIDE EDGE OF STEM WALL ABOVE GRADE
INSIDE LINE OF STEM WALL BELOW GRADE
OUTSIDE LINE OF FOOTING BELOW GRADE
2X FLOOR FRAMING ABOVE
5/8" DIA. x 12" ANCHOR BOLTS,MINIMUM 9" EMBEDMENT FROM ENDS OF SOLE PLATE 2 PER SOLE PLATE MINIMUM

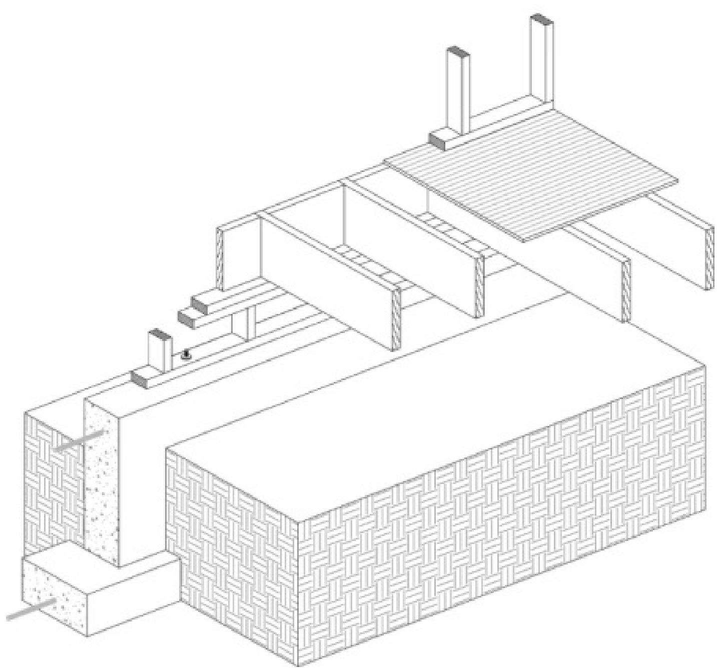
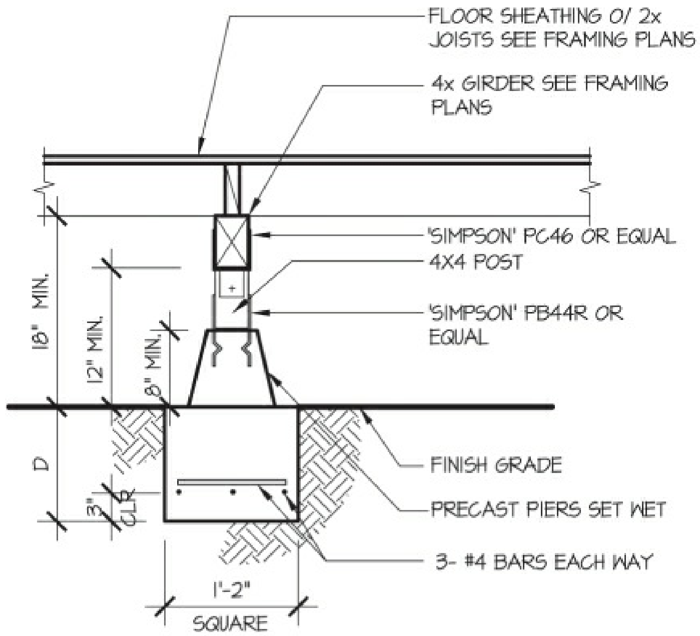
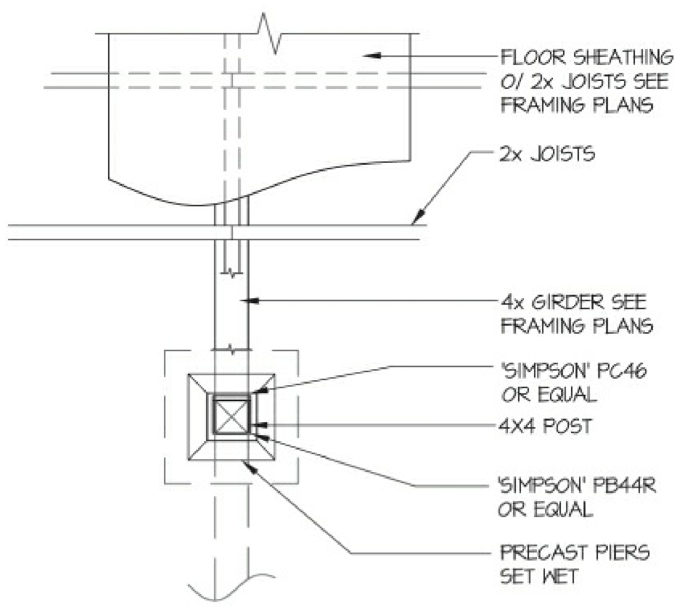


Figure 9.10 Raised wood exterior bearing footing detail.

When laying out the foundation plan for a wood floor system, provide intermediate supporting elements located between exterior and interior bearing footings. You can do this with a pier and girder system, which can be spaced well within the allowable spans of the floor joists selected. (This layout will be reviewed later in the discussion of the foundation plan.) The girder…on…pier detail can be sketched in the same way as the previous details. Figure 9.11 describes the concrete pier in plan view. The pier spacing depends on the size of floor girder selected. With a 4 × 6 girder, a 5′ to 7′ spacing is recommended under normal floor loading conditions. Regional building codes help you to select floor joists and girder sizes relative to allowable spans.


FLOOR SHEATHING O/ 2x
JOISTS SEE FRAMING PLANS
4x GIRDER SEE FRAMING
PLANS
'SIMPSON' PC46 OR EQUAL
4X4 POST
'SIMPSON' PB44R OR
EQUAL
18" MIN.
12" MIN.
8" MIN.
FINISH GRADE
PRECAST PIERS SET WET
D
3" CLR
3- #4 BARS EACH WAY
1'-2"
SQUARE


FLOOR SHEATHING
O/ 2x JOISTS SEE
FRAMING PLANS
2x JOISTS
4x GIRDER SEE
FRAMING PLANS
'SIMPSON' PC46
OR EQUAL
4X4 POST
'SIMPSON' PB44R
OR EQUAL
PRECAST PIERS
SET WET

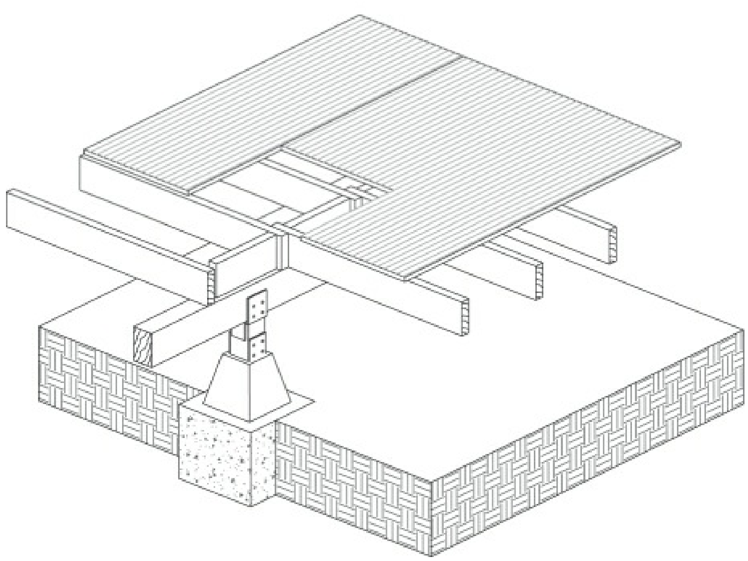


Figure 9.11 Pier and girder detail.

Drawing the Foundation Plan

Begin the foundation plan by drawing the outside line of the exterior walls, the centerline of the interior load…bearing walls (walls supporting ceiling, floor, and roof), and curb and stud edges that define a transition between the wood floor members and the concrete floor. It is not necessary to locate non…bearing wall conditions for wood floors, because floor girders can be used to support the weight of the wall or double floor joists.

As a review of this procedure, Figure 9.12 shows a foundation with wood floor construction, incorporating the plan views shown in Figures 9.9 through 9.11. The floor plan is the same one used for the concrete floor foundation plan. The spacing for floor girders and the concrete piers supporting the girders is based on the selected floor joist size and girder sizes. The floor girders can be drawn with a broken line; the piers, being above grade, should be drawn with a solid line. Dimension the location of all piers and girders. Wherever possible, locate floor girders under walls. Show the direction of the floor joists and their size and spacing directly above the floor girders. The fireplace foundation and reinforcing information can be designated as indicated earlier.

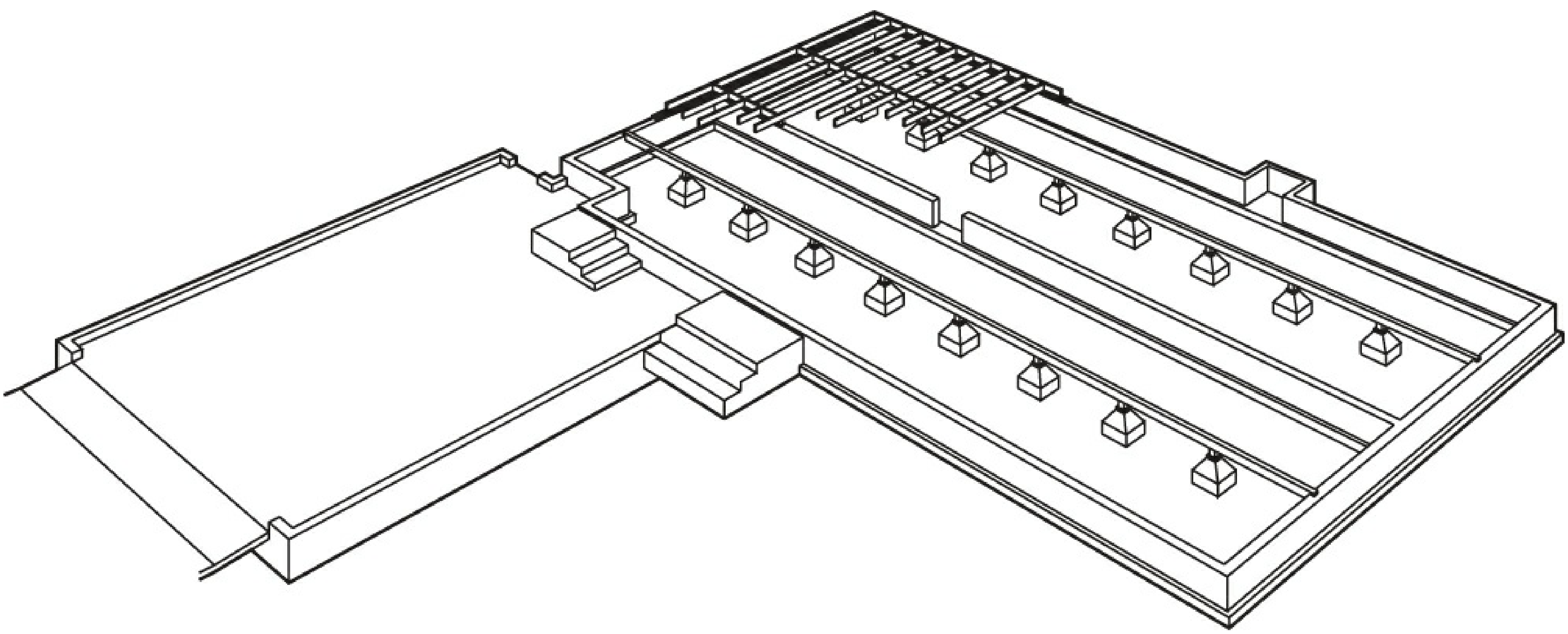


Figure 9.12 Foundation plan for a raised wood floor.

The foundation plan in Figure 9.13 shows a concrete garage floor connected to a house floor system with #3 dowels at 24″ on center (or as local code dictates). This call…out should also be designated for other concrete elements, such as porches and patios. If a basement exists, the supporting walls can be built of concrete block. The concrete…block wall will be crosshatched on the foundation plan to indicate masonry construction. See Figure 9.14. The footing system will be referenced and detailed as seen in Figure 9.15.

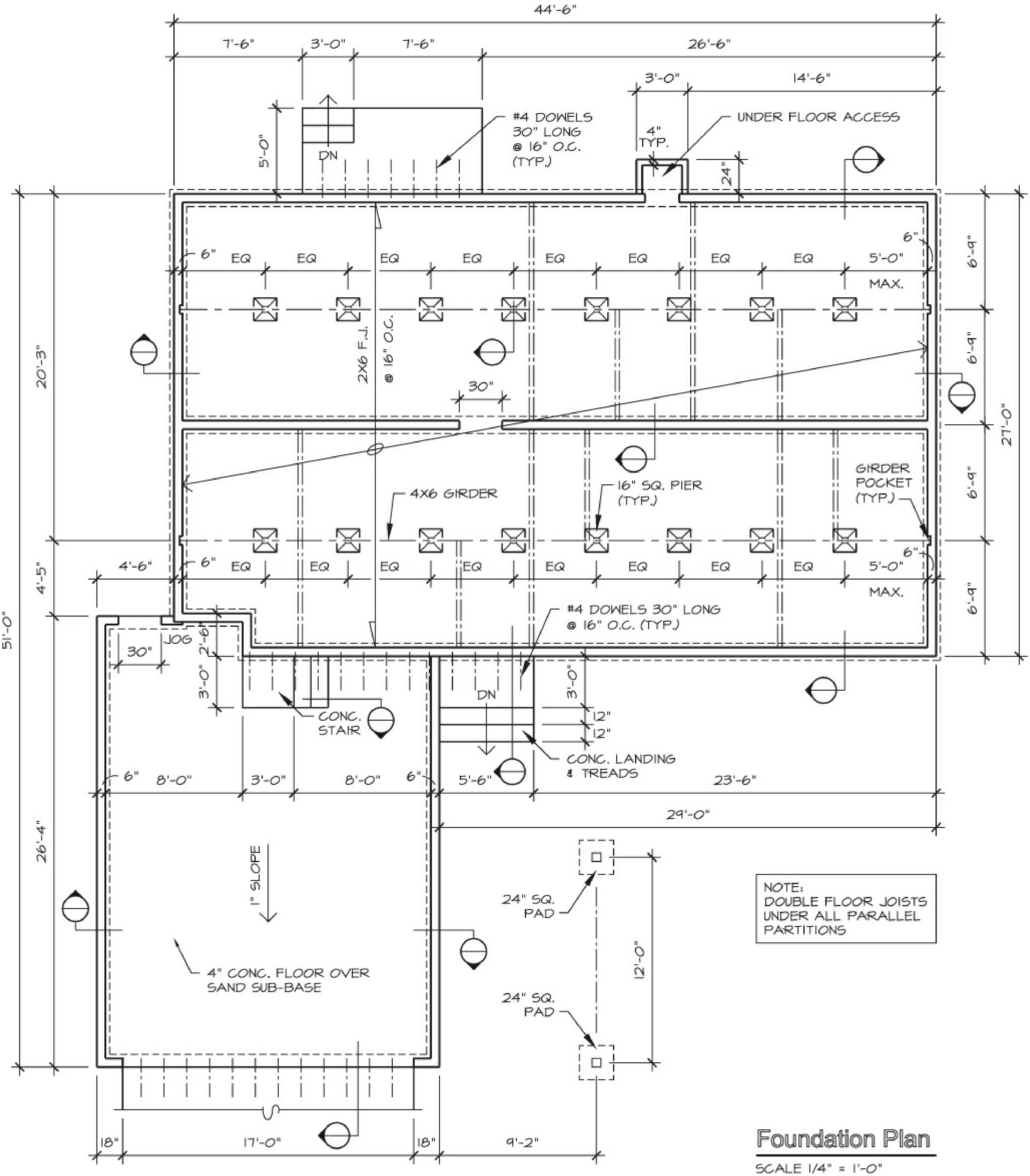


Figure 9.13 Foundation plan showing dowel ties.

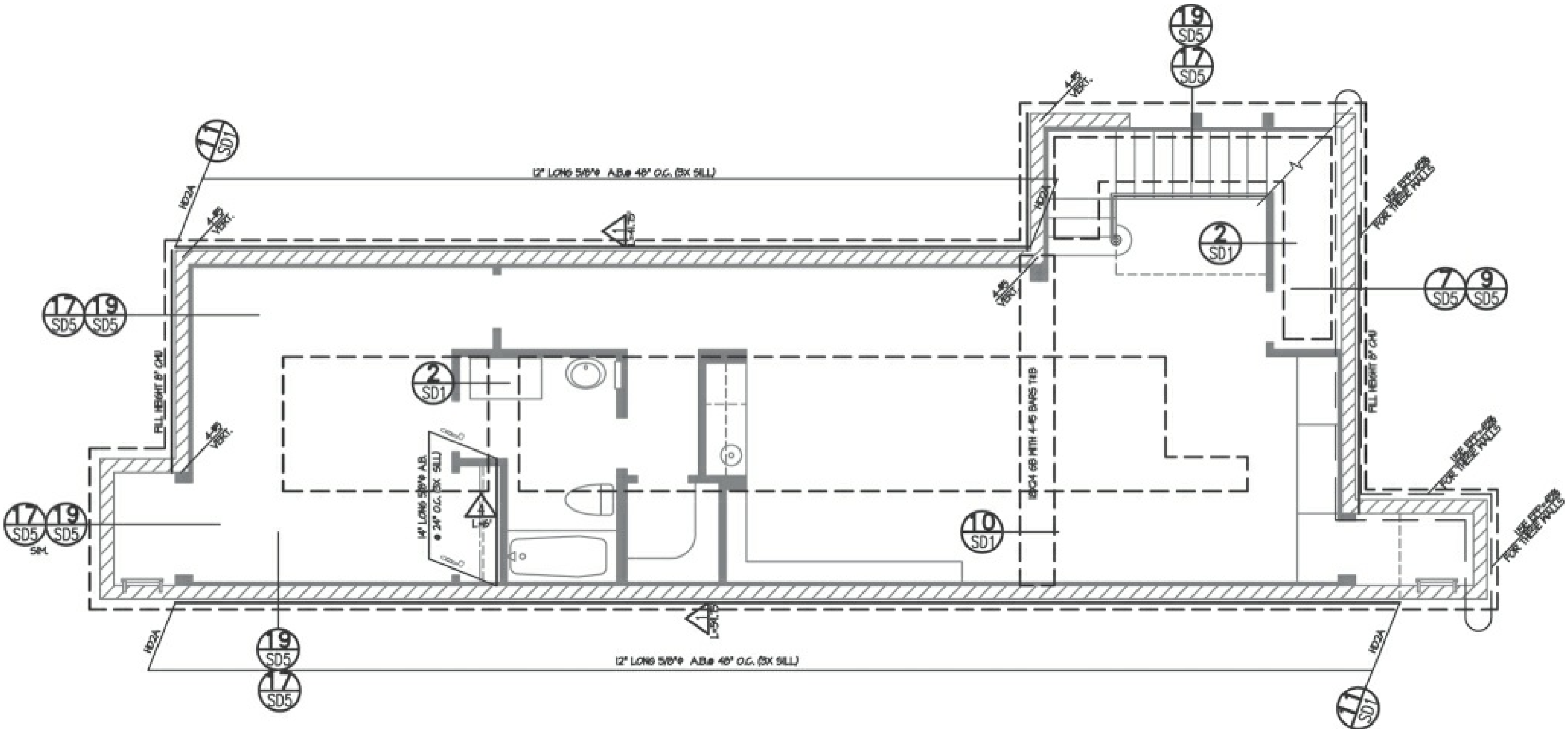
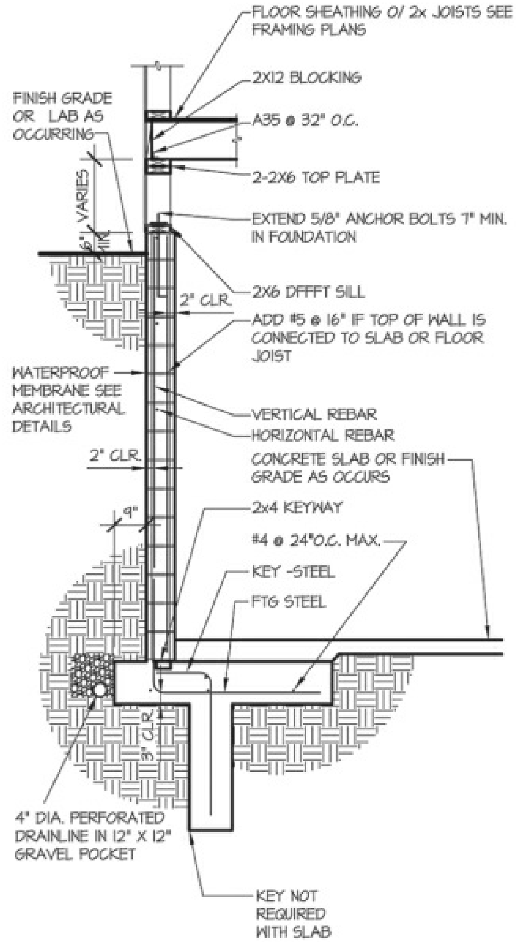
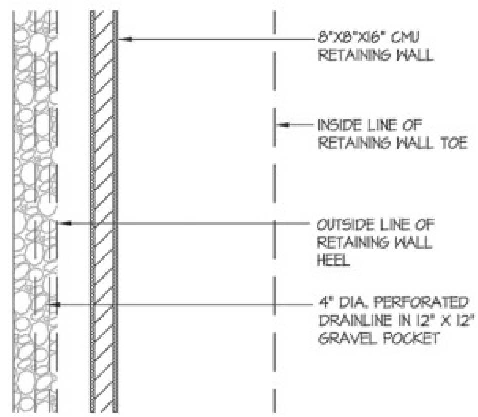


Figure 9.14 Basement foundation plan.

(Courtesy of Mr. and Mrs. Givens.)


FLOOR SHEATHING O/ 2x JOISTS SEE FRAMING PLANS
2X12 BLOCKING
A35 @ 32" O.C.
2-2X6 TOP PLATE
EXTEND 5/8" ANCHOR BOLTS 7" MIN. IN FOUNDATION
2X6 DFFFT SILL
2" CLR.
ADD #5 @ 16" IF TOP OF WALL IS CONNECTED TO SLAB OR FLOOR JOIST
FINISH GRADE OR LAB AS OCCURRING
6" VARIES
6" MIN.
WATERPROOF MEMBRANE SEE ARCHITECTURAL DETAILS
VERTICAL REBAR
HORIZONTAL REBAR
2" CLR.
CONCRETE SLAB OR FINISH GRADE AS OCCURS
9"
2x4 KEYWAY
#4 @ 24"O.C. MAX.
KEY -STEEL
FTG STEEL
3" CLR.
4" DIA. PERFORATED DRAINLINE IN 12" X 12" GRAVEL POCKET
KEY NOT REQUIRED WITH SLAB


8"X8"X16" CMU RETAINING WALL
INSIDE LINE OF RETAINING WALL TOE
OUTSIDE LINE OF RETAINING WALL HEEL
4" DIA. PERFORATED DRAINLINE IN 12" X 12" GRAVEL POCKET

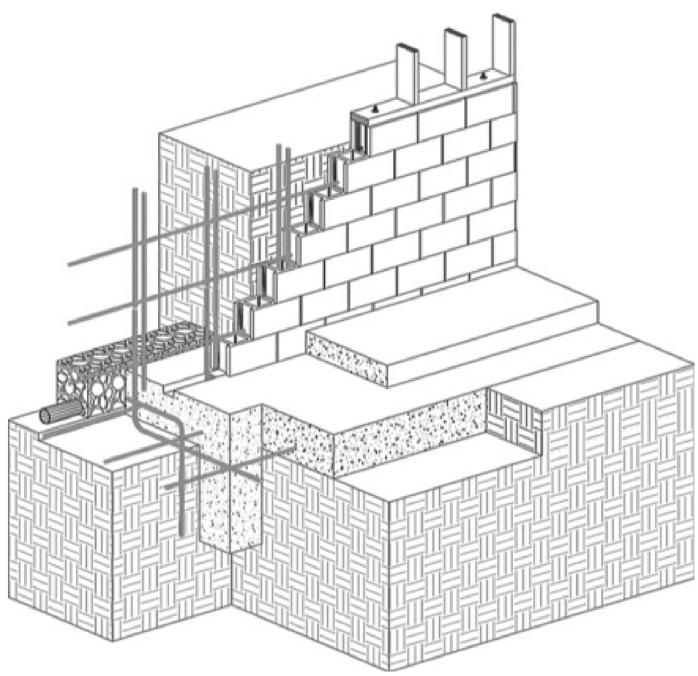


Figure 9.15 Concrete…block retaining wall at basement.

Incorporate dimensioning and foundation detail symbols the same way you did for a concrete foundation. In this instance, however, the detail reference symbol shows arrowheads on the circular symbols, as recommended by state and national standards. An important note to be located on the foundation plan drawing is the number of foundation vents required, and their sizes, material, and location. This requirement is established by governing building codes.

The foundation plan is ideally suited for computer drawing. There are two main reasons for this. As every trained manual drafter knows, the repetitious drawing of piers and girders is a thing of the past, as is the drawing of dotted or hidden lines around the perimeter of the stem wall on the foundation. On the computer, you just change the layer and line type, and offset the lines, and you immediately have the outline of a footing or foundation.

Foundation Details for a Wood Floor Foundation

Finished drawings for the foundation details can be drafted with call…outs and dimensions for each specific detail. As with a concrete floor foundation, sizes, depths, and reinforcing requirements vary regionally. Finished details for exterior and interior bearing footings, as well as a typical pier and girder, are shown in Figures 9.9 through 9.11. Figure 9.16 illustrates the use of concrete…block stem wall for a foundation supporting a wood floor. Figure 9.17 combines Figure 9.10 with a porch and stair connected to the exterior foundation detail. Here, dowels have been added to tie the concrete porch to the building, and metal flashing has been used to protect against rot from water seepage.

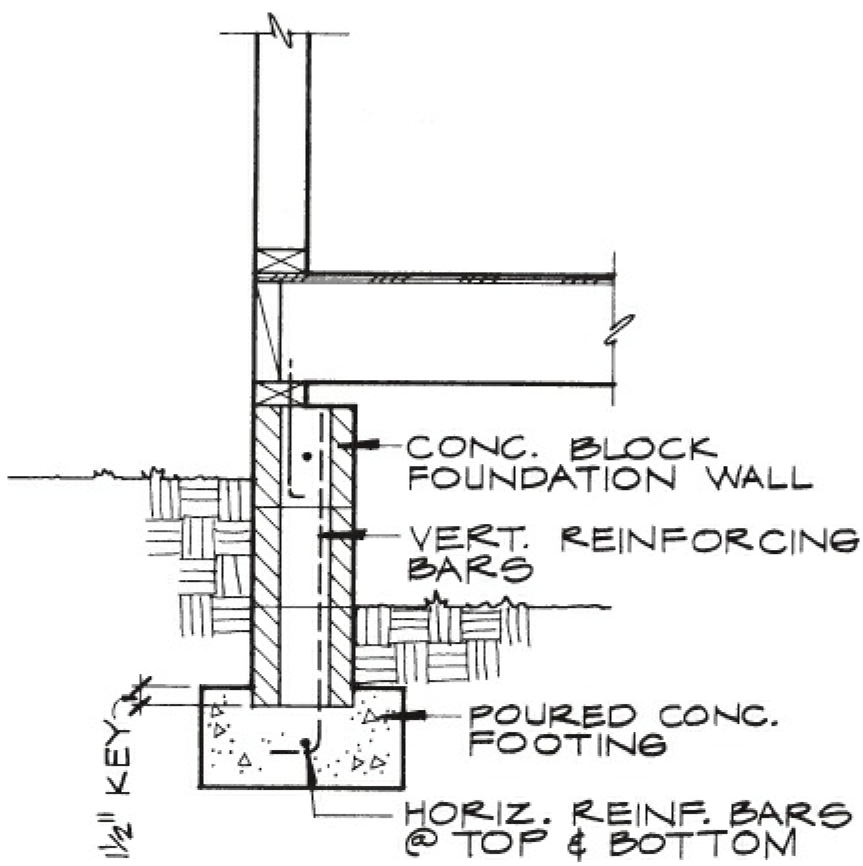


Figure 9.16 Concrete…block foundation wall supporting a wood floor.

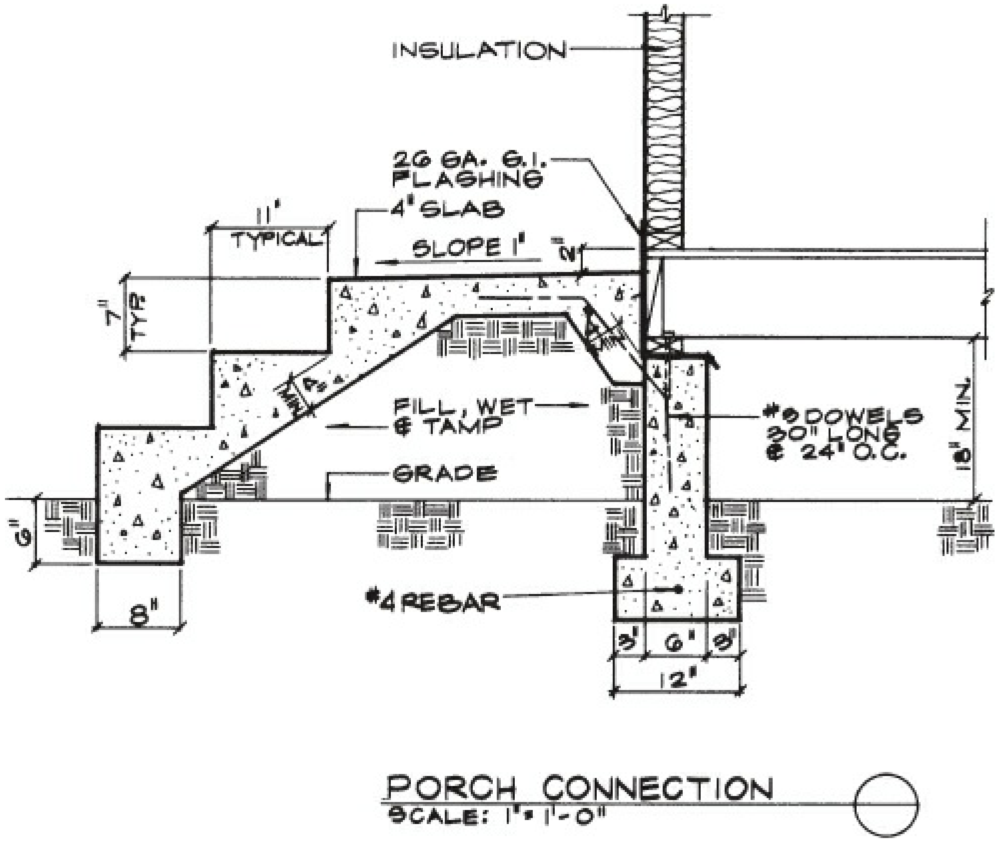
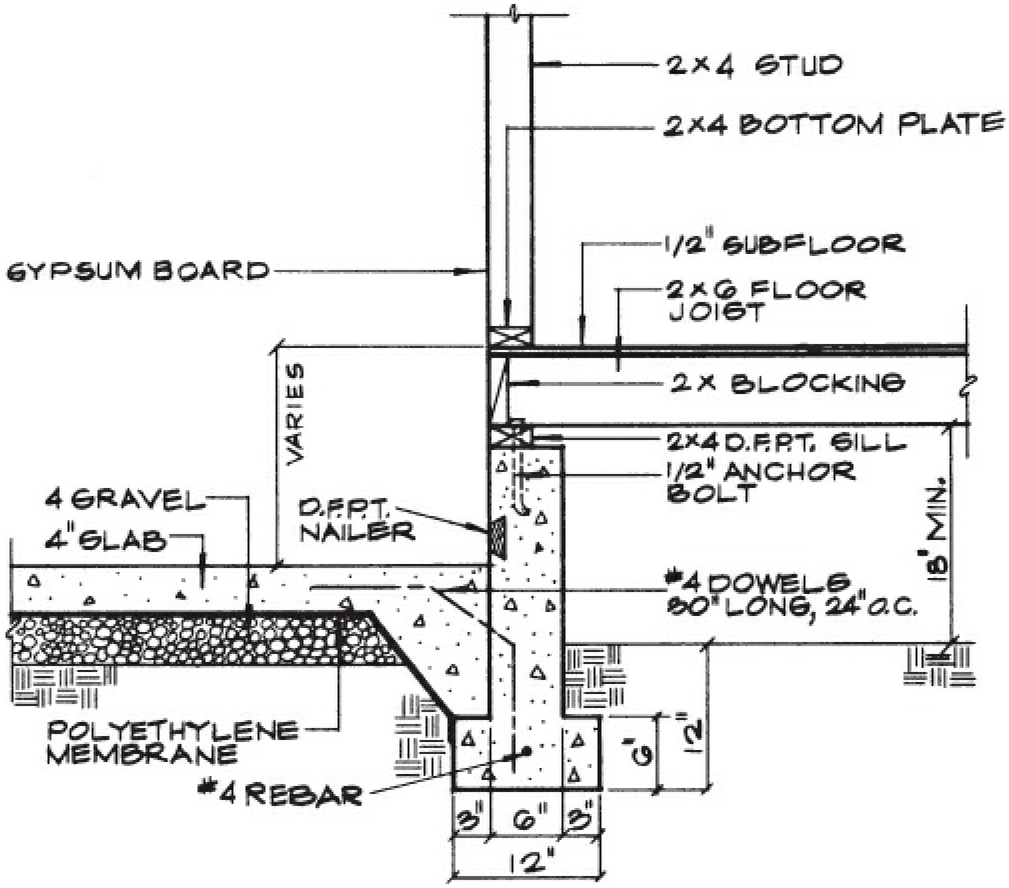


Figure 9.17 Drafted detail of a porch connection.

Figure 9.18 shows a foundation detail through the garage concrete floor and house floor. This important detail shows the placement of dowels and provisions for a nailer in which a finished interior material can be secured at the concrete foundation wall. Remaining foundation sections are drafted in the same way, using investigative sketches for reference.



[Figure 9.18](#) Drafted detail of change of level from a wood floor to a concrete slab.

EXAMPLES

Example 1: A Building with Masonry Walls

When projects use concrete or masonry for exterior and interior walls, the walls may continue down the concrete footing. [Figure 9.19](#) shows an exterior masonry wall and concrete footing. If interior walls are also constructed of masonry, the foundation section is similar to [Figure 9.19](#). Drawing the foundation plan using masonry as the foundation wall requires delineation of the foundation walls by crosshatching those areas representing the masonry.

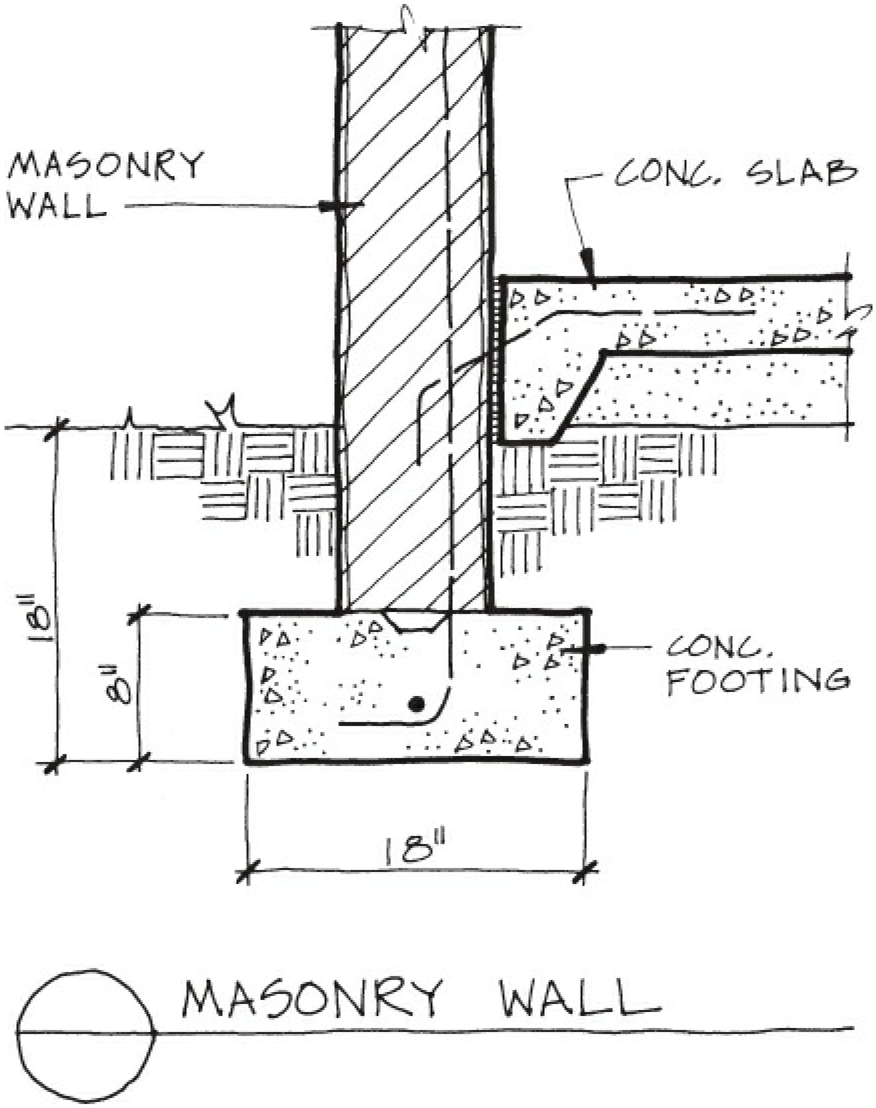


Figure 9.19 Exterior masonry wall and footing.

The foundation plan, shown in Figure 9.20, defines all the masonry wall locations as per Figure 9.19. The footings are drawn with a broken line. For this project, **pilasters** are required to support steel roof beams. A *pilaster* is a masonry or concrete column designed to support heavy axial and/or horizontal loads. The footing width is not called out, but rather refers to the foundation plan for a specific pilaster footing dimension. Many projects use a schedule, because the total loads acting on the pilaster vary based on location.

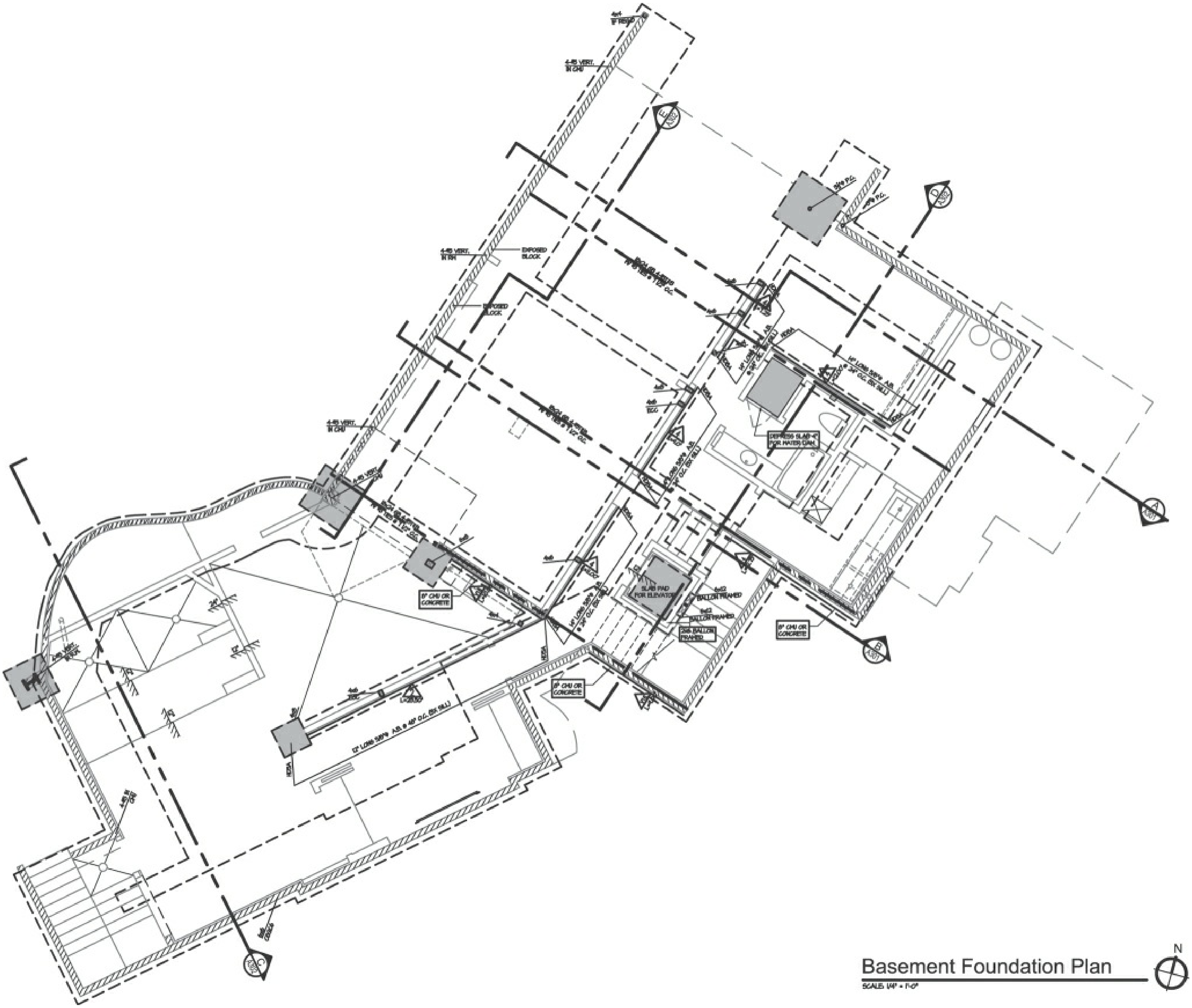
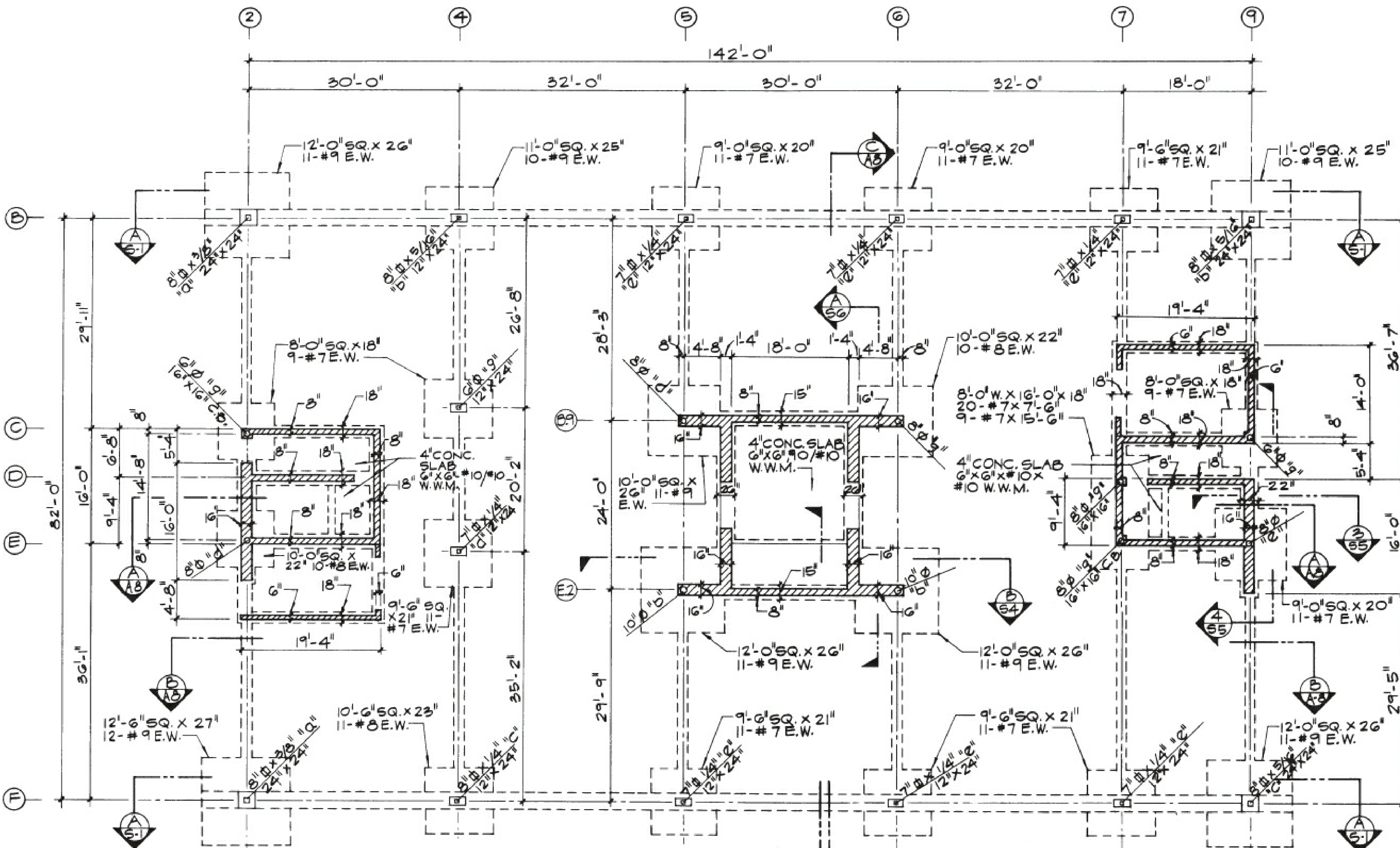


Figure 9.20 Foundation plan layout with masonry walls.

(Courtesy of Bailey residence.)

An example of a pad schedule is shown in Figure 9.21. Locate the pad schedule directly on the foundation plan sheet for ease of reference. It should show dimensions for all footings, walls, and pad locations, with reference symbols clearly defined for specific conditions. Similar notes are provided for items such as ramp and floor slopes, pilaster sizes, and required steel reinforcing.



LEGEND

COL. SIZE (STEEL) — 8" Ø "g" 12"x24"

BASE ℞ SYMBOL SEE SCHEDULE

COL. PAD SIZE (CONC.)

FOUNDATION PLAN

SCALE: 1/8"=1'-0"

BASE ℞ SCHEDULE			
SYM.	SIZE		THK.
a	18" SQ.	X	1/2"
b	17" "	X	13/8"
c	16" "	X	1/4"
d	15" "	X	1/8"
e	14" "	X	1"
f	13" "	X	7/8"
g	12" "	X	3/4"

Figure 9.21 Foundation plan: Concrete pads.

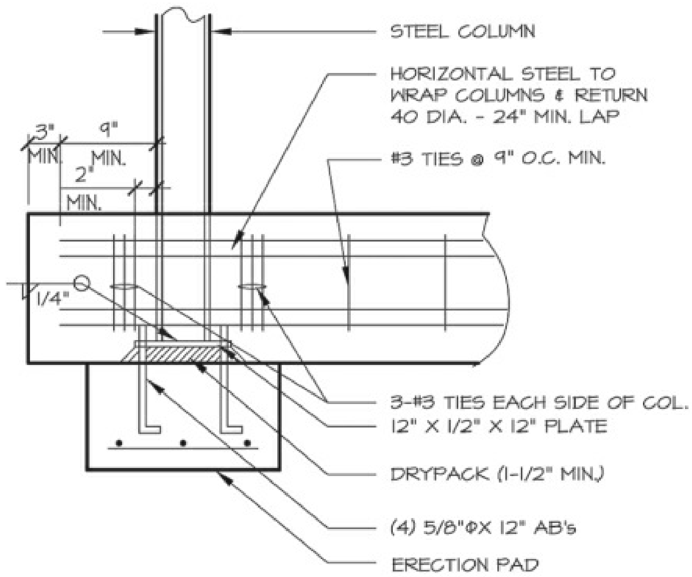
(Courtesy of Westmount, Inc. Real Estate Development.)

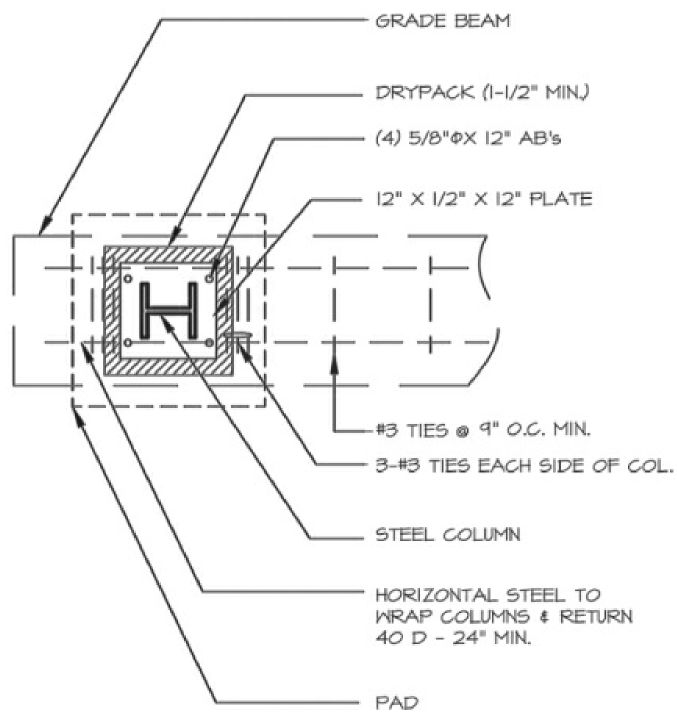
Example 2: A Foundation Using Concrete Pads and Steel Columns

The way foundation plans are drawn varies, depending on the method of construction for a specific structure. The example here is of a structure requiring concrete pads to support steel columns, with a continuous footing to support masonry walls.

Steel columns are also required to support heavy axial loads, and they, in turn, require a foundation. These foundation members are commonly referred to as concrete piers or **concrete pads**. The size of these pads varies with different loading conditions. Because of the various pad sizes, you may need to use a column pad schedule. This schedule should note the column designation, size, depth, and required steel reinforcing.

This foundation plan, as Figure 9.21 shows, is handled differently from the foundation plan in Example 1. First, establish the column locations as they relate to the **axial reference locations**; then draw and delineate masonry walls. Concrete pads located under a concrete floor are represented with a broken line. See Figure 9.21. Figure 9.22 provides a visual example of this column pad footing detail in section. The column pad sizes may vary due to varying loads, and may be sized using a pad schedule or noted directly on the foundation plan. In this case, sizes are noted on the foundation plan. At the bottom of the foundation plan drawing, provide a **legend** defining the size and shape of the steel column and the base stem that supports it.


STEEL COLUMN
HORIZONTAL STEEL TO WRAP COLUMNS & RETURN 40 DIA. - 24" MIN. LAP
3" MIN.
9" MIN.
2" MIN.
#3 TIES @ 9" O.C. MIN.
1/4"
3-#3 TIES EACH SIDE OF COL.
12" X 1/2" X 12" PLATE
DRYPACK (1-1/2" MIN.)
(4) 5/8"ΦX 12" AB's
ERECTION PAD


GRADE BEAM
DRYPACK (1-1/2" MIN.)
(4) 5/8"ΦX 12" AB's
12" X 1/2" X 12" PLATE
#3 TIES @ 9" O.C. MIN.
3-#3 TIES EACH SIDE OF COL.
STEEL COLUMN
HORIZONTAL STEEL TO WRAP COLUMNS & RETURN 40 D - 24" MIN.
PAD

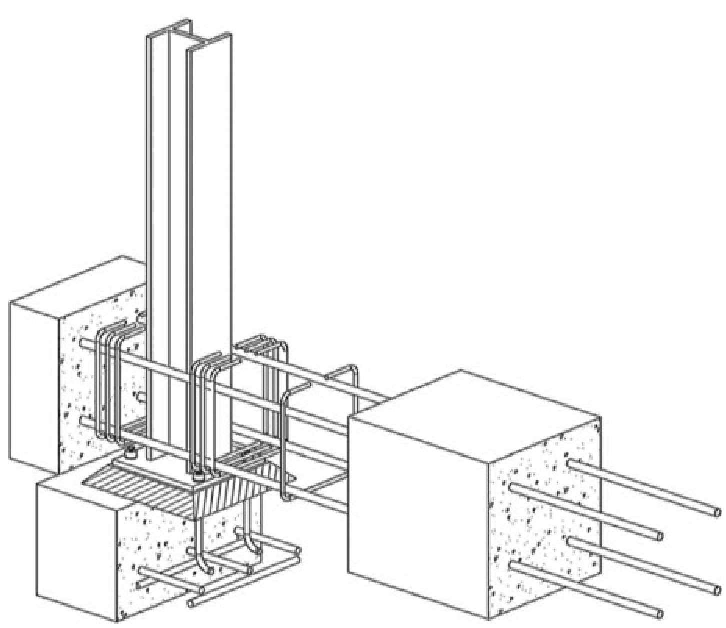


Figure 9.22 Column…to…footing detail.

Because of all the critical information required in the field, a schedule for column base plates and their required anchorage may be necessary. Put this on the plan. Dimensioning this type of foundation depends on the axial reference locations, which are identical to the floor…plan referencing. Other foundation conditions are dimensioned from these axial reference lines.

After you complete all the necessary dimensioning, show section reference symbols and notes. Figure 9.21 has a double broken line representing a continuous footing underneath, which connects to all the concrete pads. The main purpose of this footing is to provide continuity for all the components of the foundation.

The concrete pads are the main supports for this structure. Figure 9.23 shows the trenching and some formwork for a concrete pad. Note particularly the placement of the reinforcing steel and the footing, which is used to tie all the pads together. After the concrete is poured and anchor bolts embedded, the steel column with the attached base plate is bolted to the concrete pad. See Figure 9.24.

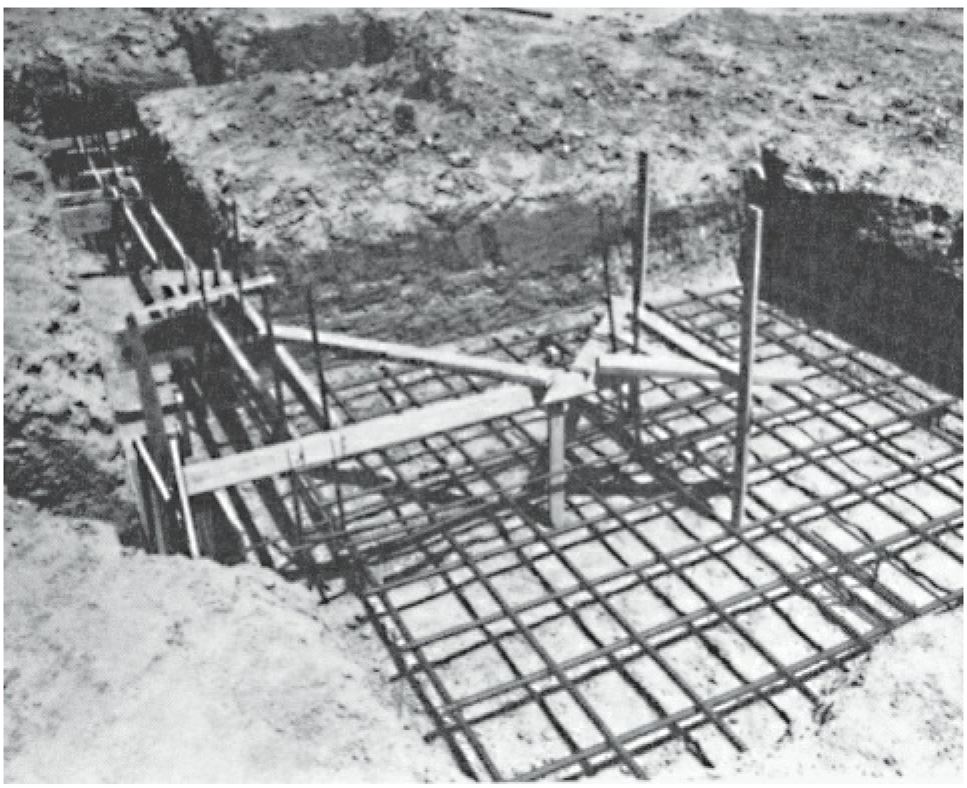


Figure 9.23 Forming for concrete pad.

(Courtesy of William Boggs Aerial Photography. Reprinted with permission.)

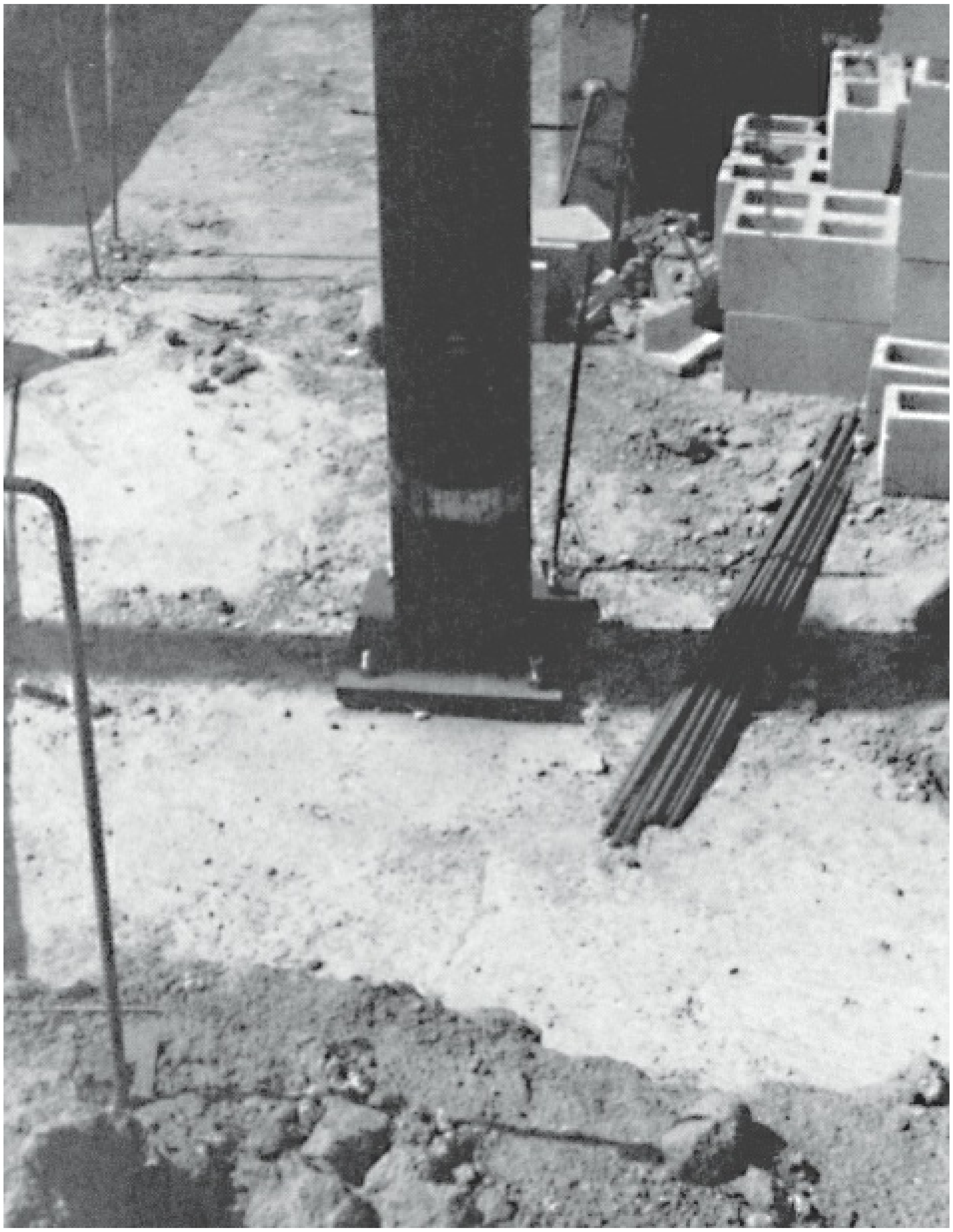


Figure 9.24 Steel column on concrete pad.

When columns are used for structural support, concrete caissons may be needed in unfavorable soil conditions. A **concrete caisson** is a reinforced column designed specifically for the loads it will support and is located at a depth that has good soil… bearing capacity. The concrete caisson shown in Figure 9.25 is used on a sloping site to provide firm support for a wood column, which in turn is part of the structural support for a building. Figure 9.26 shows a job site drilling rig making holes for concrete caissons.

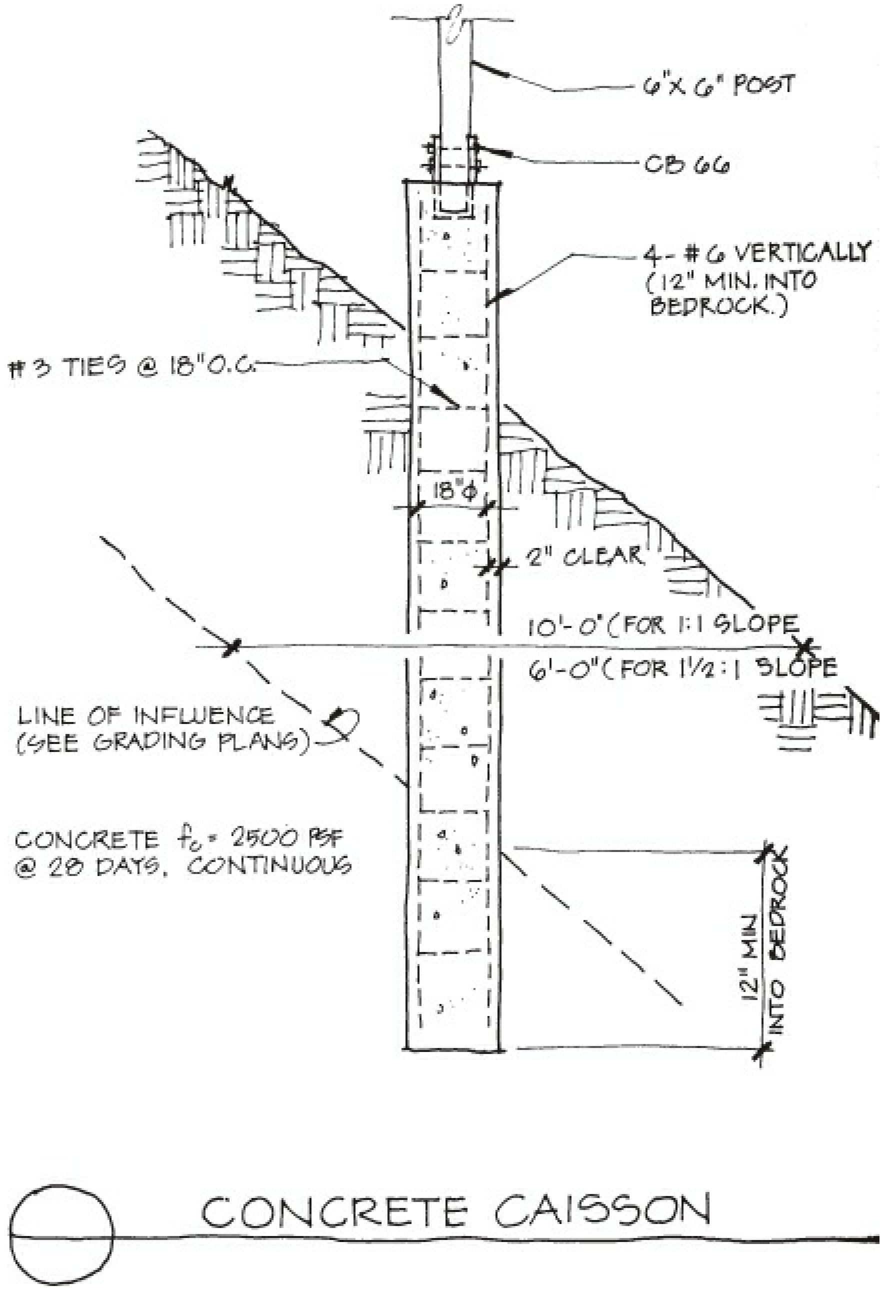


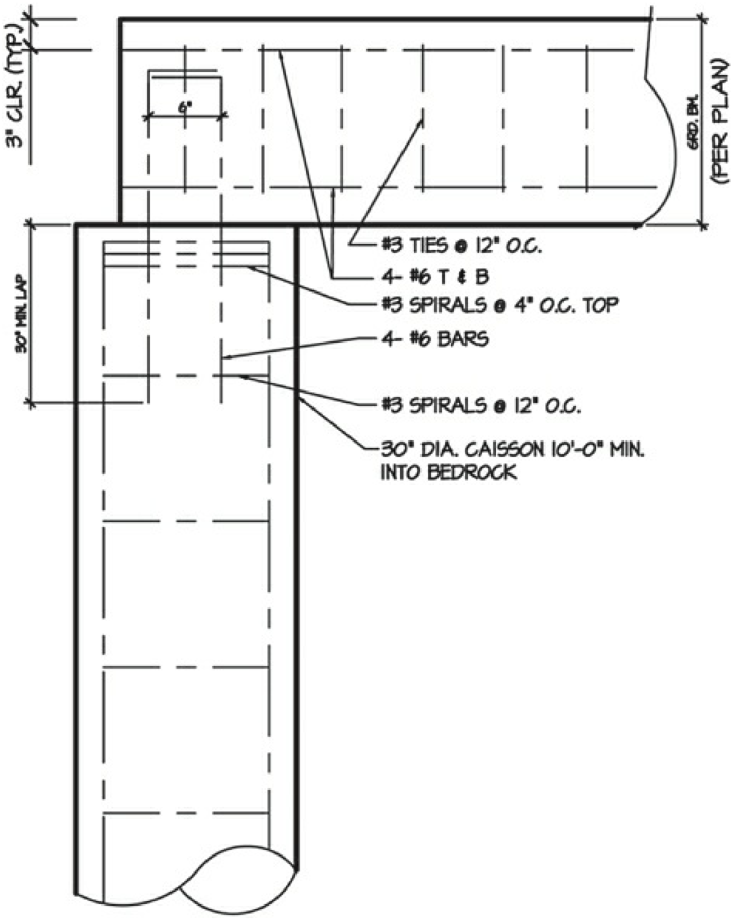
Figure 9.25 Concrete caisson.

Figure 9.26 Drilling holes for concrete caissons.

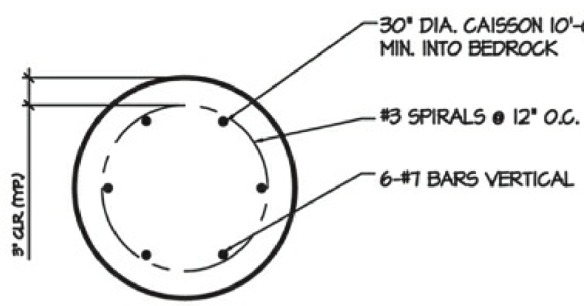
(Courtesy of William Boggs Aerial Photography. Reprinted with permission.)

Most construction sites that require caissons use them in multiple locations where they are all tied together. The system of caissons is tied at the top with a **grade beam**. This beam acts as a grid of beams that ties all the caissons together and provides the foundation for walls or posts that will sit on top of them. The idea is to provide support

for walls where the foundation does not rely on soil…bearing capacity up high but down low, at the bottom of the caisson, where soil…bearing capacities are more ideal. If you visualize a table and its legs, the grade beam is the table top and the legs of the table are the caissons. See Figure 9.27.



3" CLR. (TYP.)
6"
(PER PLAN)
30" MIN. LAP
#3 TIES @ 12" O.C.
4- #6 T & B
#3 SPIRALS @ 4" O.C. TOP
4- #6 BARS
#3 SPIRALS @ 12" O.C.
30" DIA. CAISSON 10'-0" MIN.
INTO BEDROCK



30" DIA. CAISSON 10'-0"
MIN. INTO BEDROCK
#3 SPIRALS @ 12" O.C.
6-#7 BARS VERTICAL
3" CLR. (TYP.)

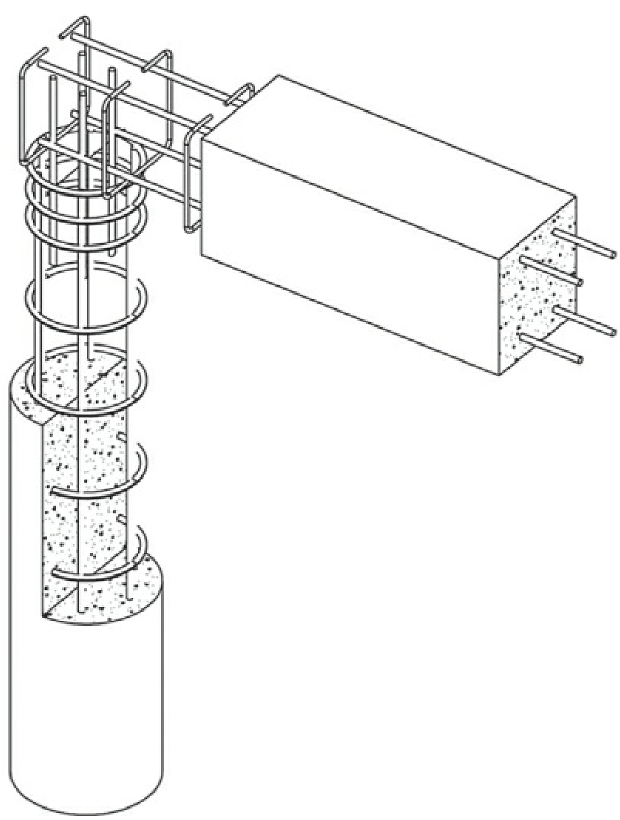
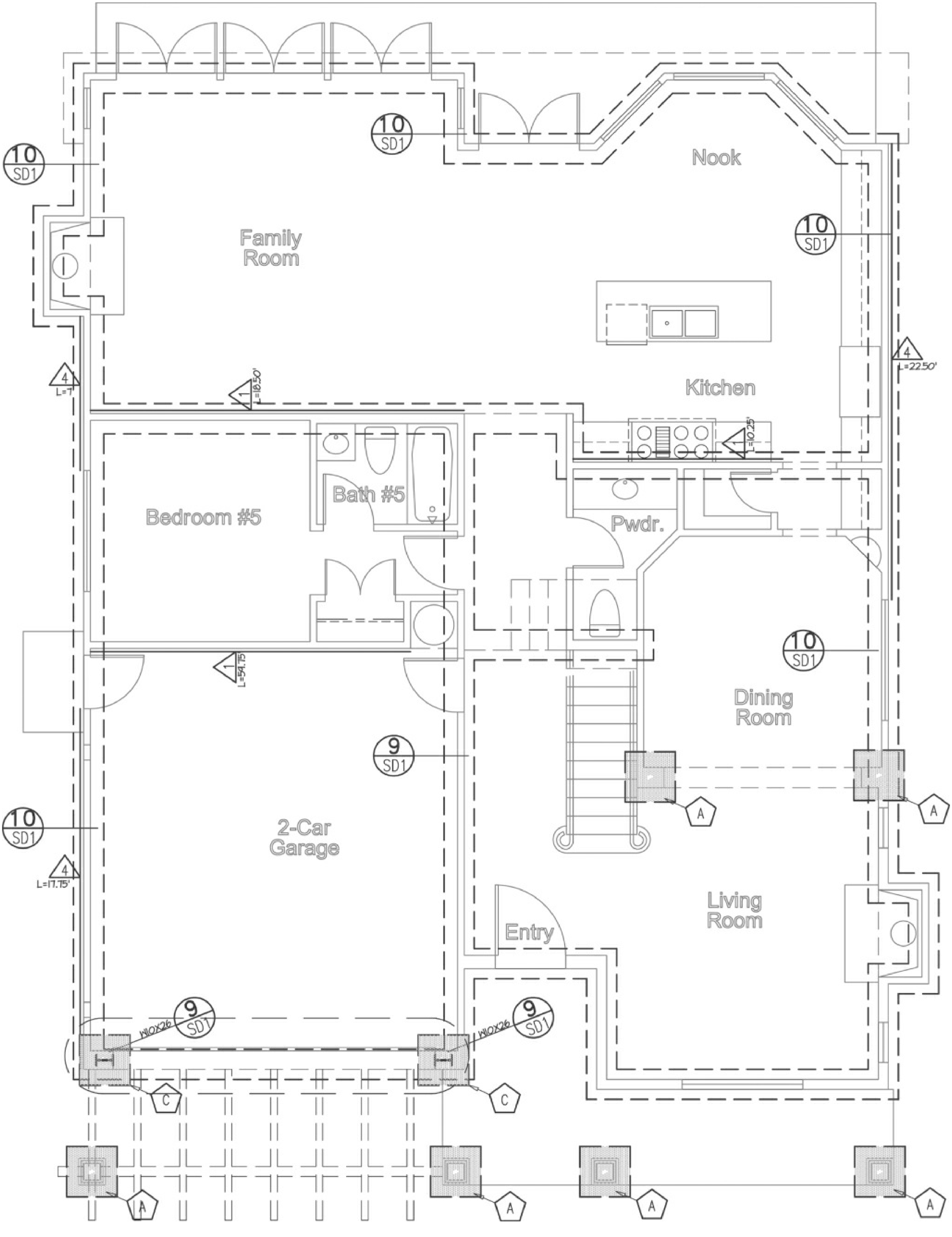


Figure 9.27 Caisson design with grade beam system.

Example 3: A Concrete Floor at Ground…Floor Level

The foundation plan in Figure 9.28 is for a small two…story residence with a concrete floor at the ground…floor level. The plan view drawing of the foundation sections is similar to those in Figures 5.42, 9.2, and 9.3.



Family Room
Nook
Kitchen
Bedroom #5
Bath #5
Pwdr.
Dining Room
2-Car Garage
Living Room
Entry
10 SD1
9 SD1
4 L=7'
4 L=22.50'
4 L=17.75'
1 L=18.50'
1 L=10.25'
1 L=54.75'
W10X26
A
C

Figure 9.28 Foundation plan with concrete slab floor.

Everything that is to be installed prior to the pouring of the concrete must be noted on the foundation plan. If items are located on other drawings, the foundation contractor may miss them, causing problems after the pouring. Specific locations call for anchor bolt placement, steel column embedment, post hold…down hardware, and other symbols, all explained in the legend. Dimensions for the location of all foundation walls and footings are shown with reference symbols for the various footing conditions.

Figure 9.29 demonstrates the importance of noting all the required hardware or concrete accessories on the foundation plan. You can well imagine the problems that would arise if these items were not installed before the concrete was poured. Trenching and formwork for the foundation are shown photographically in Figure 9.30. The next step in completing the foundation phase of this residence is the pouring of the concrete and finishing of the concrete floor in preparation for the wood framing. Often, a checklist is also furnished to provide specific information required for a project. See Figure 9.31.

Figure 9.29 Foundation with embedded hardware.

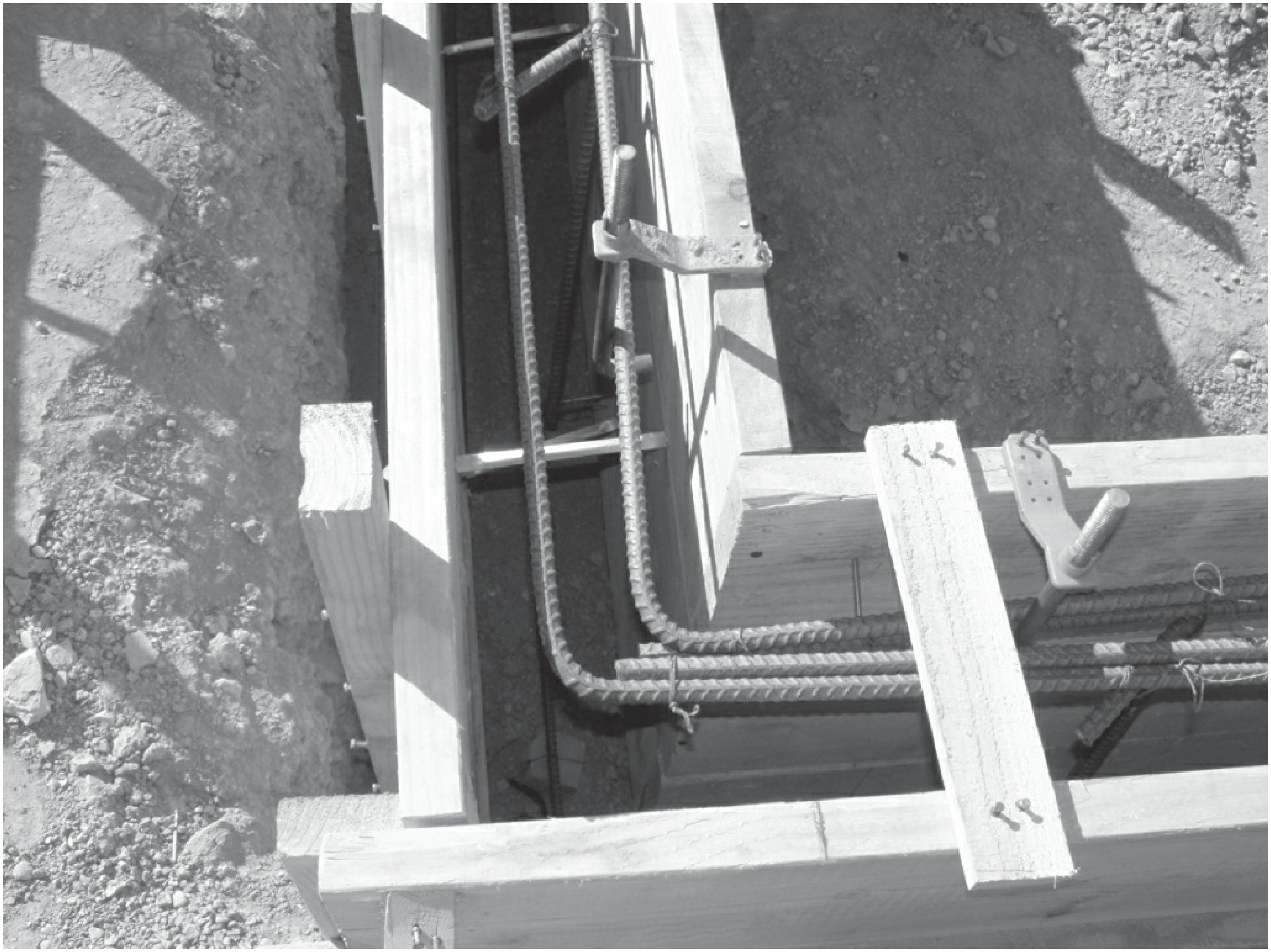


Figure 9.30 Foundation trenching, forming, reinforcement bar, and anchor bolt locating.

FOUNDATION PLAN AND DETAIL CHECKLIST

1. North arrow
2. Titles and scale
3. Foundation walls 6" (solid lines)
   a. Overall dimensions
   b. Offset dimensions (corners)
   c. Interior bearing walls
   d. Special wall thickness
   e. Planter wall thickness
   f. Garage
   g. Retaining wall

4. Footings – 12" (hidden lines)
   a. Width of footing
   b. Stepped footing as per code
   c. Fireplace footing
   d. Belled footing
   e. Grade beams
   f. Planter footing
   g. Garage
   h. Retaining wall

5. Girder (center to center)
   a. Size
   b. Direction
   c. Spacing (center to center)

6. Piers
   a. Size
   b. Spacing (center to center)
   c. Detail
      (1) 8" above grade (finish)
      (2) 8" below grade (natural)
      (3) 2 x 6 x 6 redw'd block secure to pier
      (4) 4 x 4 post
      (5) 4 x 4 girder
      (6) 2 x _ floor joist (o/c)
      (7) Subfloor 1" diagonal
         (a) T&G
         (b) Plyscord
      (8) Finish floor *usually in finish schedule

7. Porches
   a. Indicate 2" lip on foundation (min.)
   b. Indicate steel reinforcing (⅜" – 24" o.c.)
   c. Under slab note: Fill, puddle, and tamp
   d. Thickness of slab and steps.

8. Subfloor material and size
9. Footing detail references.
10. Cross-section reference
11. Column footing location and sizes
12. Concrete floors:
    a. Width of footing
    b. Stepped footing as per code
13. Fireplace foundation
14. Patio and terrace location
    a. Material
    b. See porches
15. Depressed slabs or recessed area for ceramic tile etc.
16. Double floor joist under parallel partitions
17. Joist-direction and spacing
18. Areaways (18" x 24")
19. Columns (centerline dimension and size
20. Reinforcing location and size
    a. Rods
    b. Wire mesh
    c. Chimney
    d. Slabs
    e. Retaining walls
21. Apron for garage
22. Expansion joints (20' o.c. in driveways
23. Crawl holes (interior foundation walls)
24. Heat registers in slab
25. Heating ducts
26. Heat plenum if below floor
27. Stairs (basement)
28. Detail references
    a. "Bubbles"
    b. Section direction
29. Trenches
30. Foundation details
    a. Foundation wall thickness (6" min.)
    b. Footing width and thickness (12" min.)
    c. Depth below natural grade (12" min.)
    d. 8" above finish grade (FHA) (6"-UBC)
    e. Redwood sill or as per code (2 x 6)
    f. ½" x 10" anchor bolts, 6'-0" o.c. 1' from corners, embedded 7"
    g. 18" min clearance bottom, floor joist to grade
    h. Floor joist size and spacing
    i. Subfloor (see pier detail)
    j. Bottom plate 2 x 8
    k. Studs size and spacing
    l. Finish floor (finish schedule)
31. All dimensions–coordinate with floor-plan dimensions
32. Veneer detail (check as above)
33. Areaway detail (check as above)
34. Garage footing details
35. Planter details
36. House-garage connection detail
37. Special details
38. Retaining walls over 3'-0" high (special design)
39. Amount of pitch of garage floor (direction)
40. General concrete notes
    a. Water-cement ratio
    b. Steel reinforcing
    c. Special additives
41. Note treated lumber
42. Special materials
    a. Terrazzo
    b. Stonework
    c. Wood edge

43. Elevations of all finish grades
44. Note: Solid block all joists at mid-span if span exceeds 8'-0"
45. Specify grade of lumber (construction notes)
46. Pouché all details on back of vellum
47. Indicate North arrow near plan
48. Scale used for plan
49. Scale used for details
50. Complete title block
51. Check dimensions with floor plan
52. Border lines heavy and black

Figure 9.31 Foundation plan checklist.

SUMMARY OF TYPICAL CONVENTIONS FOR FOUNDATION PLAN

Refer to Figure 9.32 as you review the items in the following list.

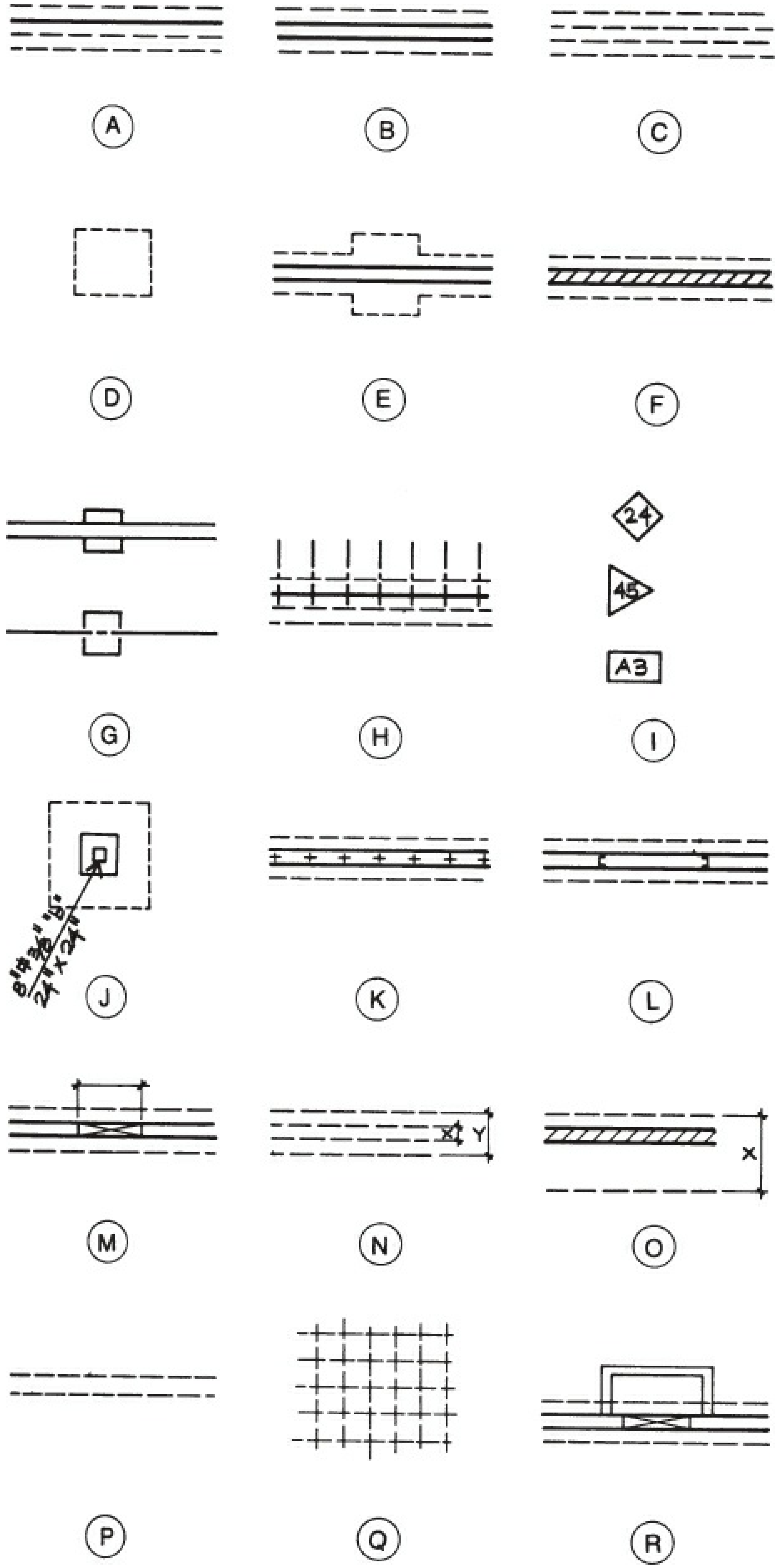


Figure 9.32 Conventions used on foundation plan.

A. Plan view of an exterior bearing footing for a slab…on…grade.

B. Plan view of a footing with a concrete curb, such as a garage. Also represents bearing

footing for a wood floor system.

C. Plan view of an interior bearing footing for a slab…on…grade system.

D. Convention could represent a pier or a concrete pad for a column.

E. A widening of the footing portion of a foundation for a column; actually a combination of B and D.

F. A plan view of a masonry wall and footing.

G. A system showing a pier and girder convention.

H. Centerlines as shown here represent dowels.

I. The diamond shape, triangle, and rectangle are used to identify such things as anchor bolt spacing, shear wall finishes, and spacing of framing anchors.

J. A multiple convention, indicating pad, pedestal, steel column, and base plate sizes. The letter refers you to a schedule in which the plate size, pad size, or even the reinforcing is described.

K. The (+) symbols represent anchor bolt locations for shear walls. This symbol should be accompanied with a note similar to the following:

L. ½″ dia. A.B. @ 12″ o.c. (shear wall).

M. The ([) shapes represent hold…downs at shear walls.

N. Shows the location of under…floor vents and/or crawl hole from one chamber of under…floor space to another. As shown, the rectangle should be dimensioned.

O. The four hidden lines shown in this convention represent an interior bearing footing for a slab…on…grade system. If the stem wall and width of the footing vary from location to location, dimensions for them are indicated right at the location on the foundation plan.

P. A masonry retaining wall. As in the previous example, the plan view could be dimensioned if these walls are of varying sizes throughout a structure.

Q. A non…bearing footing for a slab…on…grade system.

R. Matrix used to represent concrete slab reinforcement. The size of the reinforcing is noted; for example, #4 @ 18″ o.c. each way. It is not shown throughout the foundation plan, but only on a portion of it and noted as typical.

S. An under…floor access, with the rectangle having an X as the actual opening through the foundation wall. This symbol can also be used for a window well in a basement area.

EXTERIOR AND INTERIOR WALLS

Figure 9.33 shows a partial floor plan of the living room wall adjacent to the bedroom that

begins as an exterior wall and turns into an interior wall. The problem reveals itself when we remove the slab, as seen in Figure 9.34. Note that although the stem wall is not aligned, the plates are. If we align the foundation, the plates (sills) are out of alignment, resulting in a framing problem.

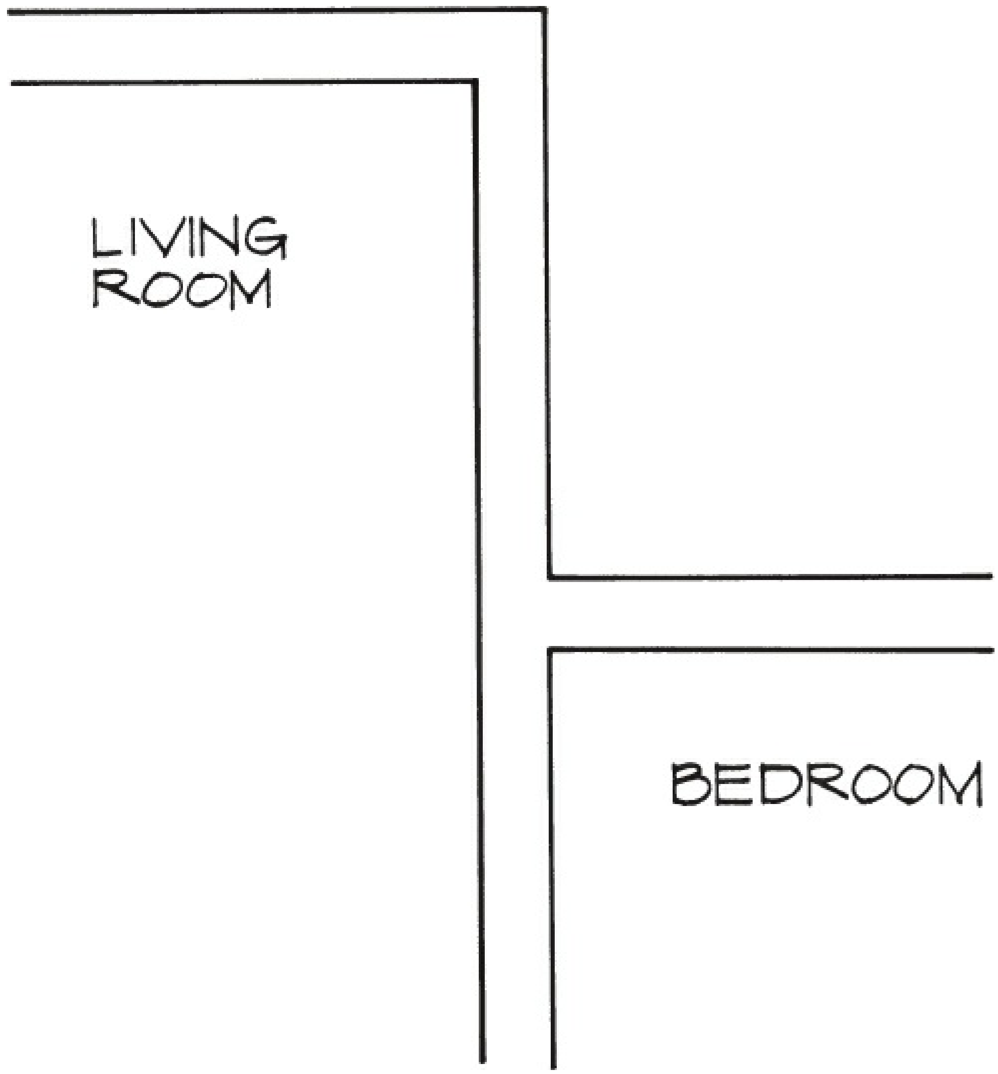


Figure 9.33 Partial floor plan.

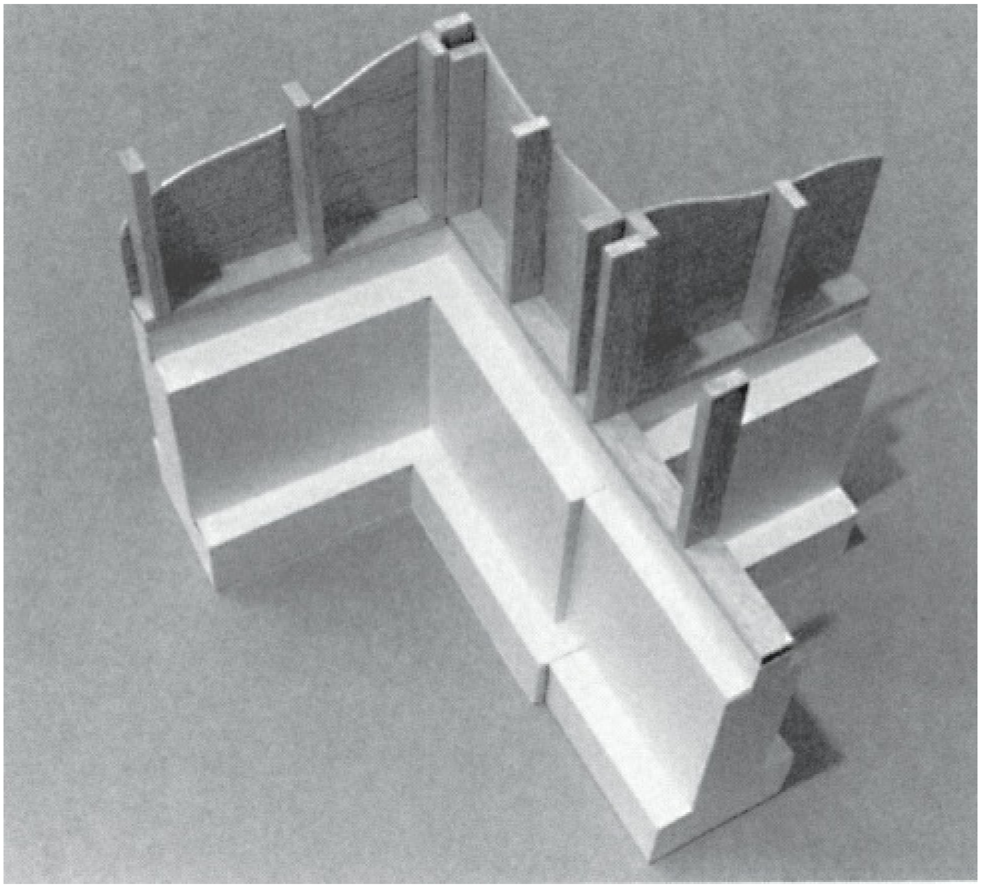


Figure 9.34 Offset in the foundation.

There are a couple of ways of representing this condition. One, as shown in Figure 9.35A, is to actually show the offset by jogging the hidden lines. Another method, as shown in Figure 9.35B, is to show the exterior/interior foundation wall as continuous and identify the jog with a note.

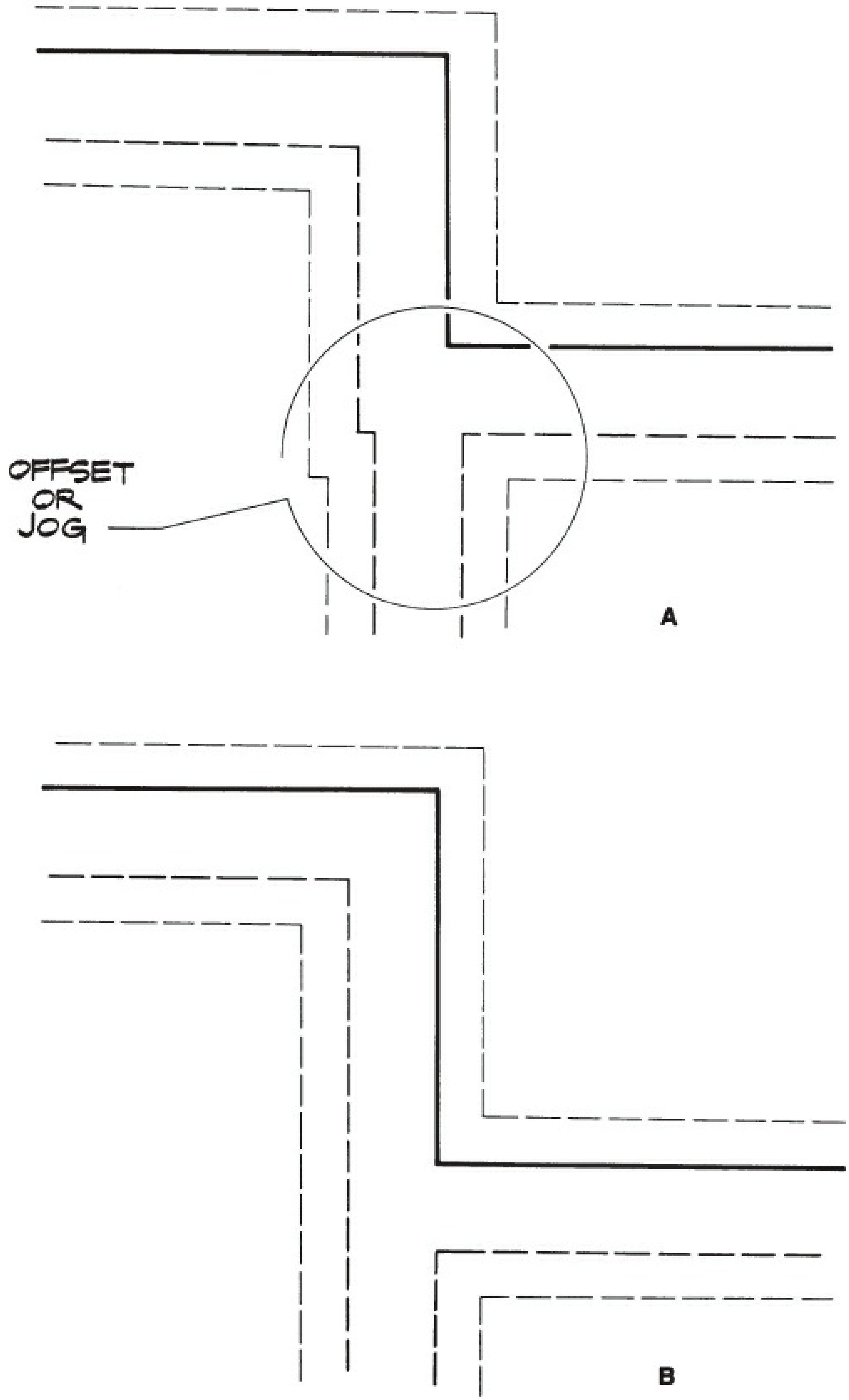
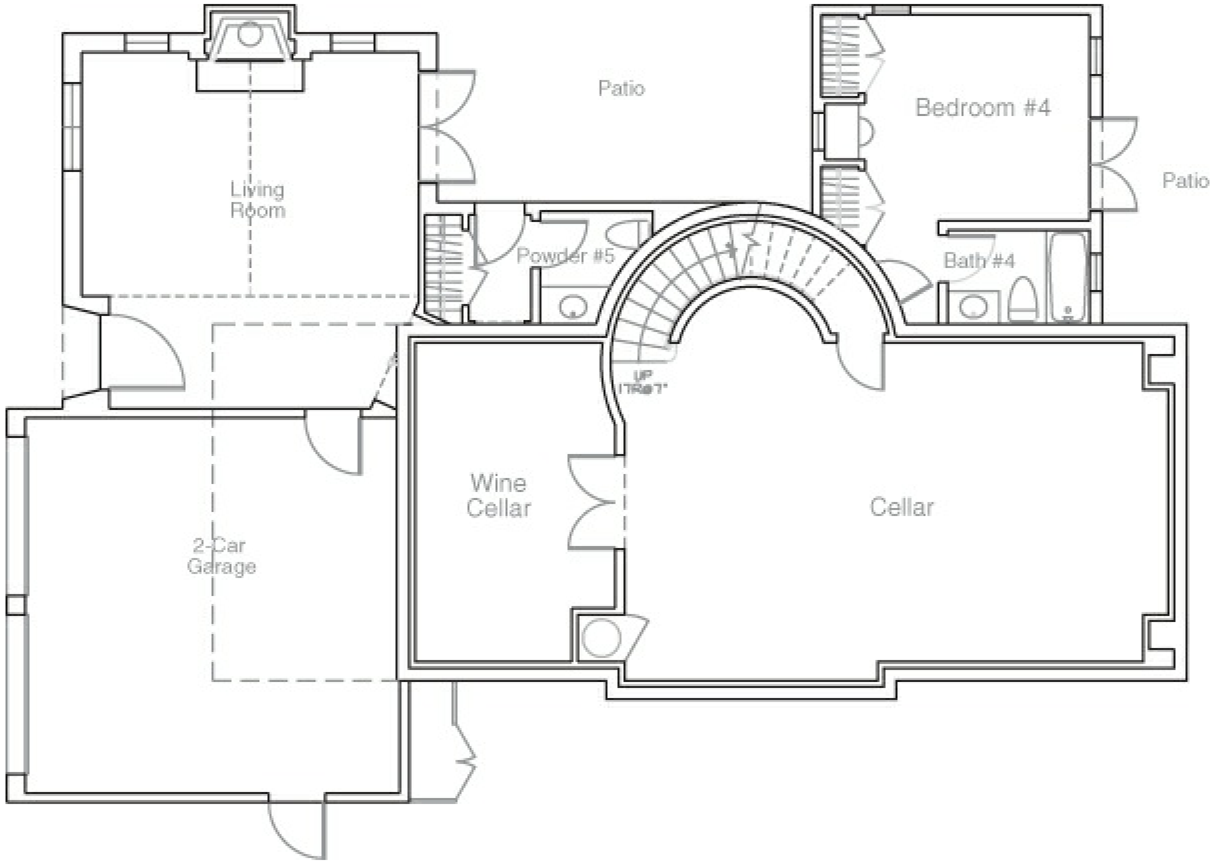


Figure 9.35 Partial foundation plan.

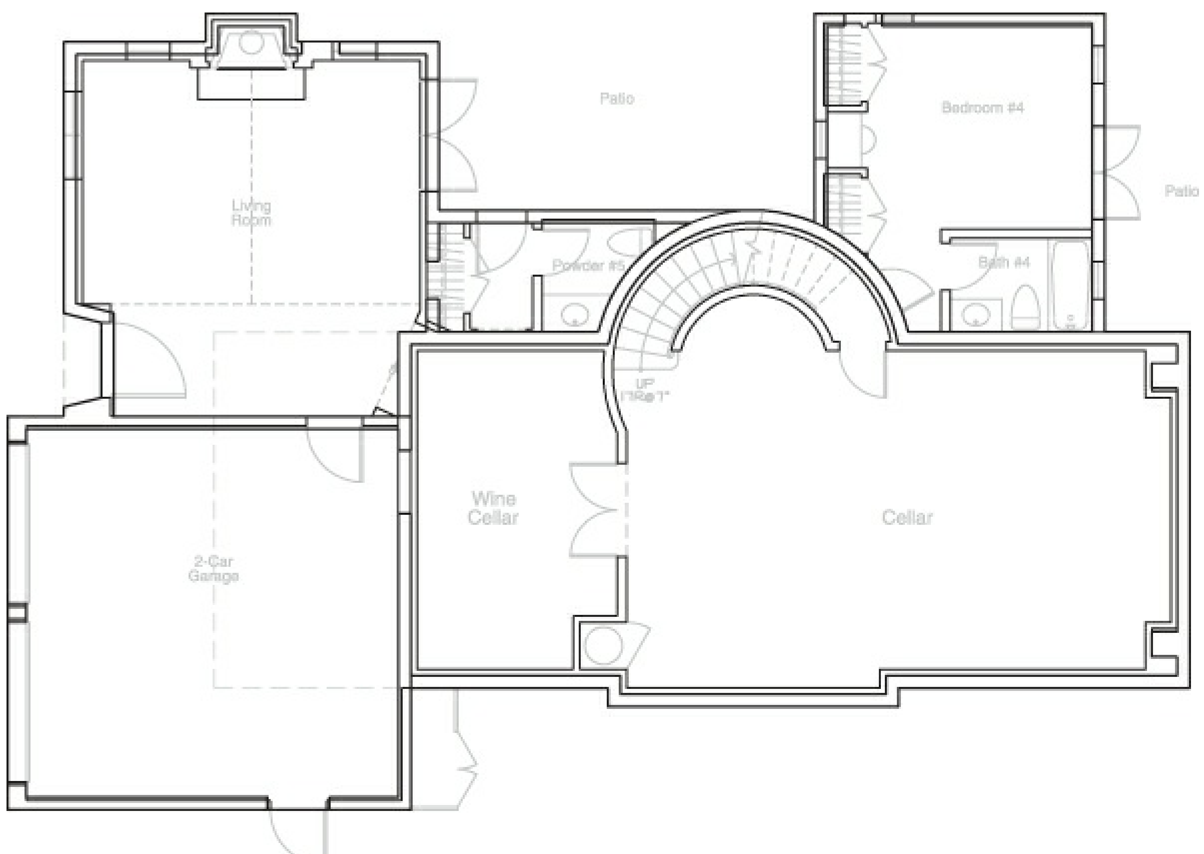
Drafting a Foundation on the Computer

Stage I (Figure 9.36). The first stage is always the datum or base stage. The floor plan must be used for the base or datum stage. XREF the floor plan.



[Figure 9.36](#) Stage I: Establishing datum (using floor plan).

Stage II ([Figure 9.37](#)). The second stage involves outlining the structure with a single line and positioning the interior bearing walls. Take care in identifying any exterior walls that become interior walls for sill (bottom plate) placement.



[Figure 9.37](#) Stage II: Outline structure.

Stage III ([Figure 9.38](#)). Locate additional items such as concrete pads and establish the configuration of the footing.

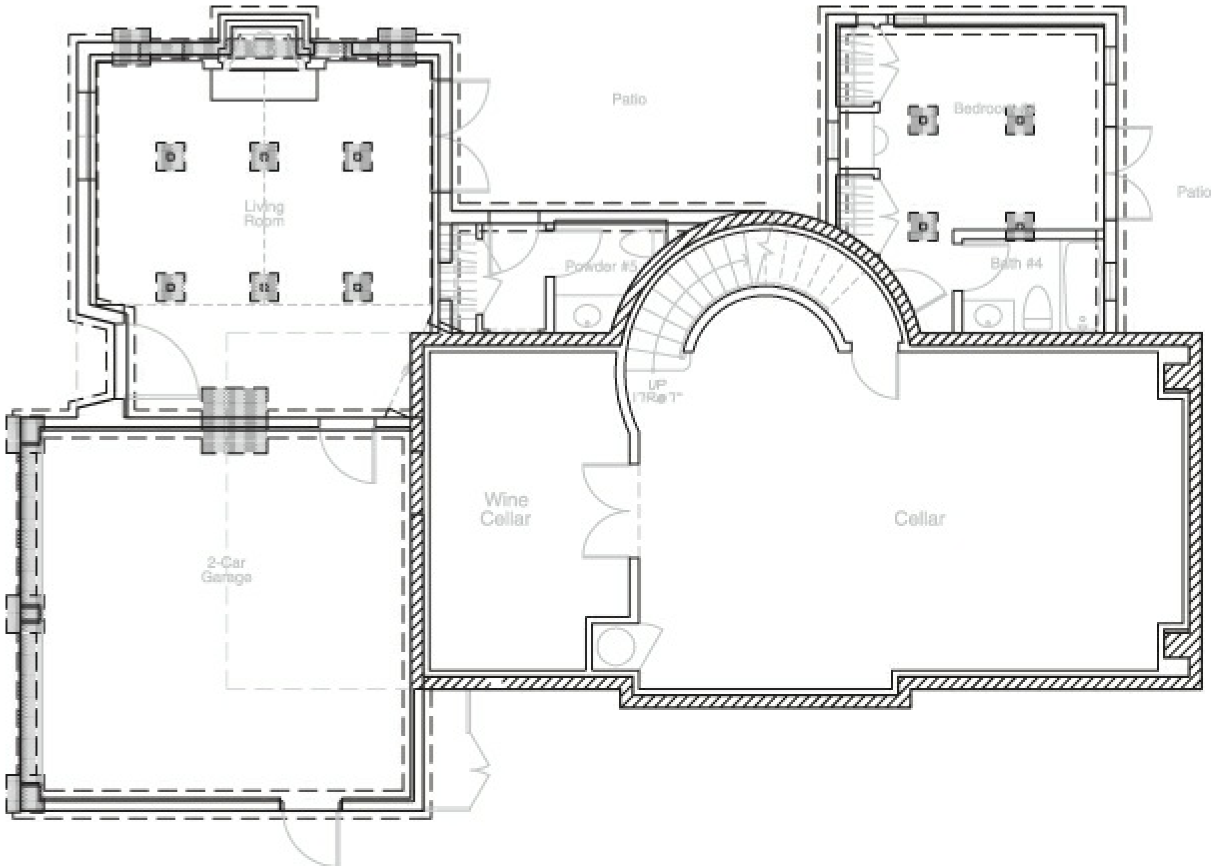


Figure 9.38 Stage III: Positioning bearing walls and posts/pads.

Stage IV ([Figure 9.39](#)). If depressed slabs are needed to accommodate materials such as ceramic tile or brick pavers, concrete steps or stairs, or elevator shafts, they are shown at this or an earlier stage. Solid lines may be changed to dotted lines at this point. It is just a matter of changing layers and changing line type.

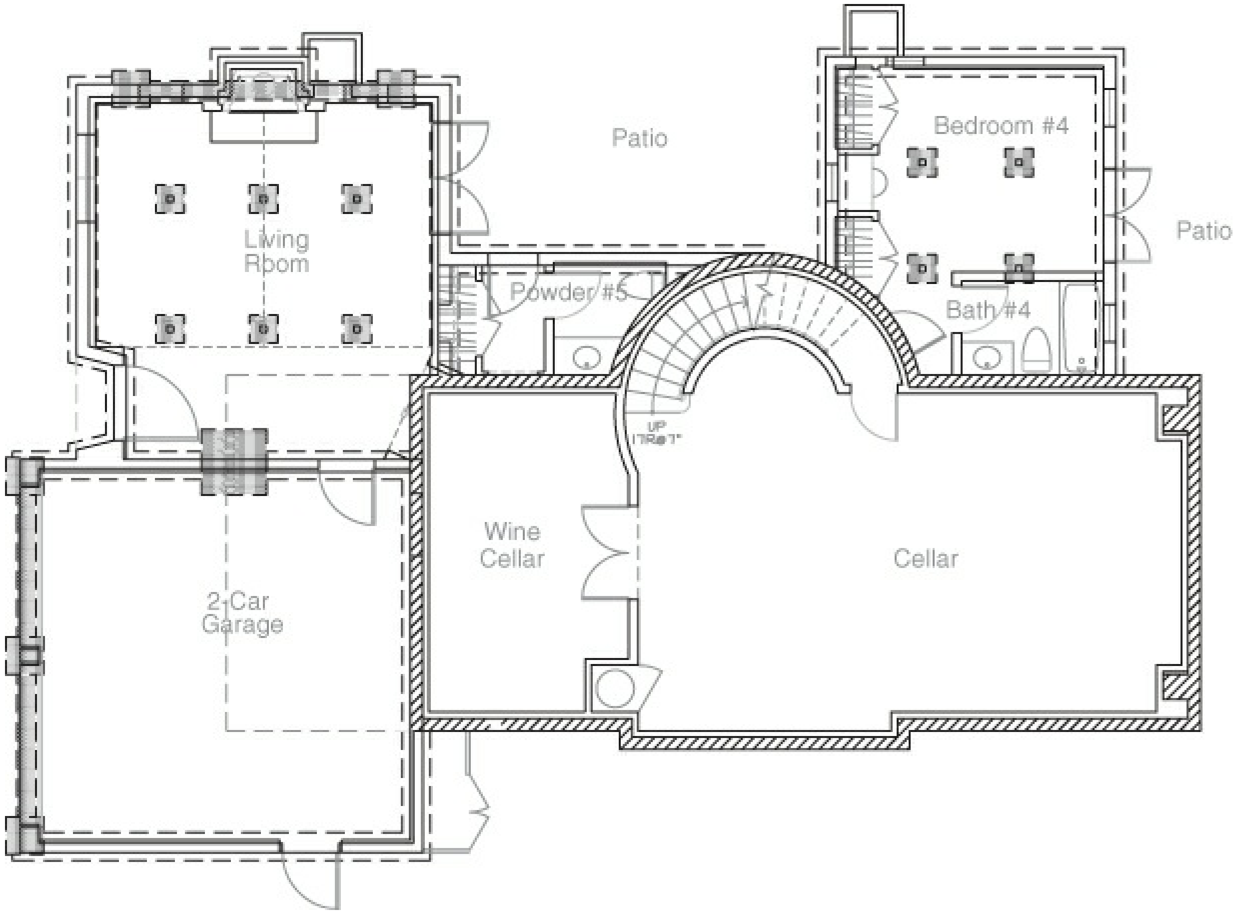
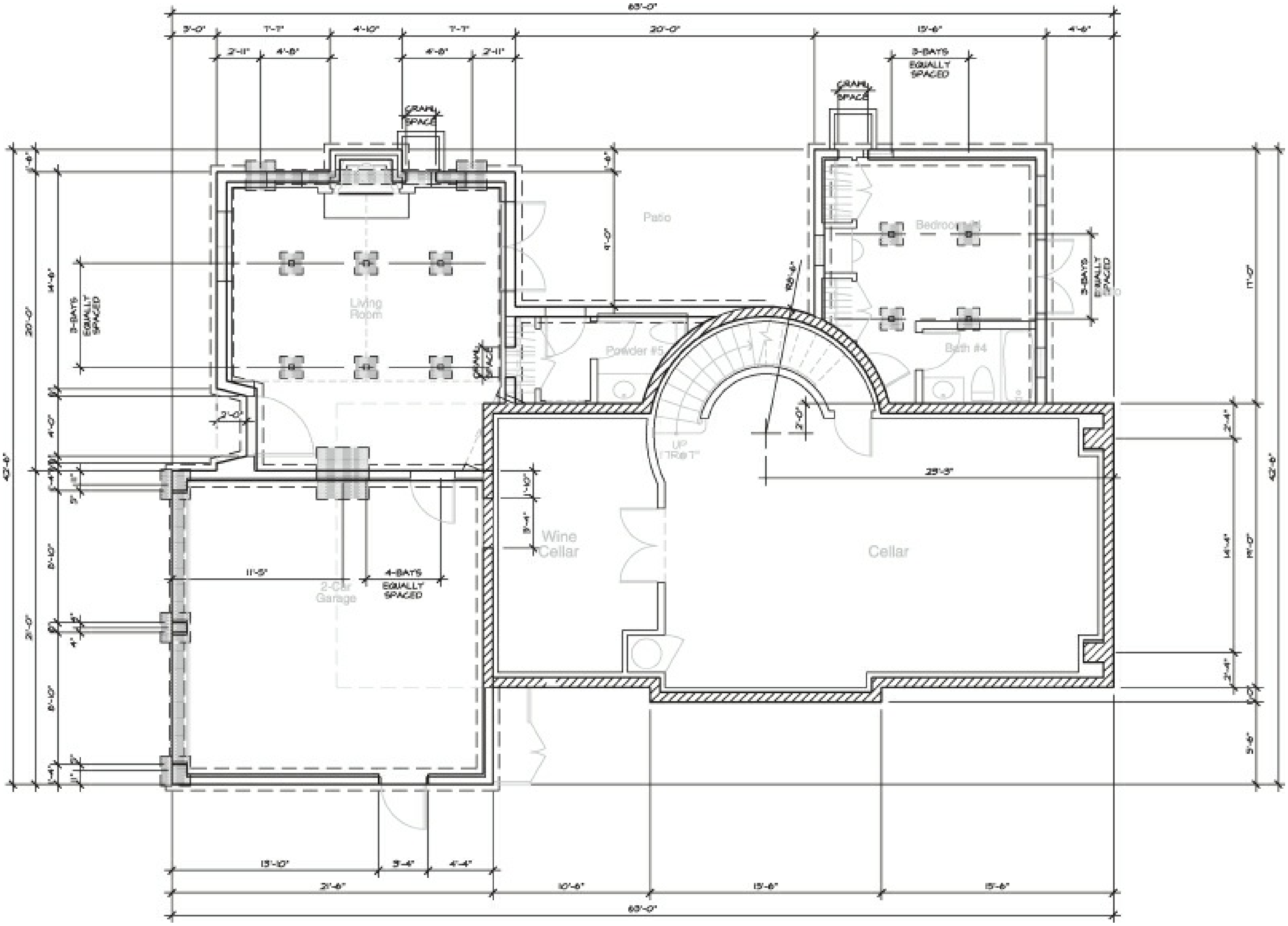


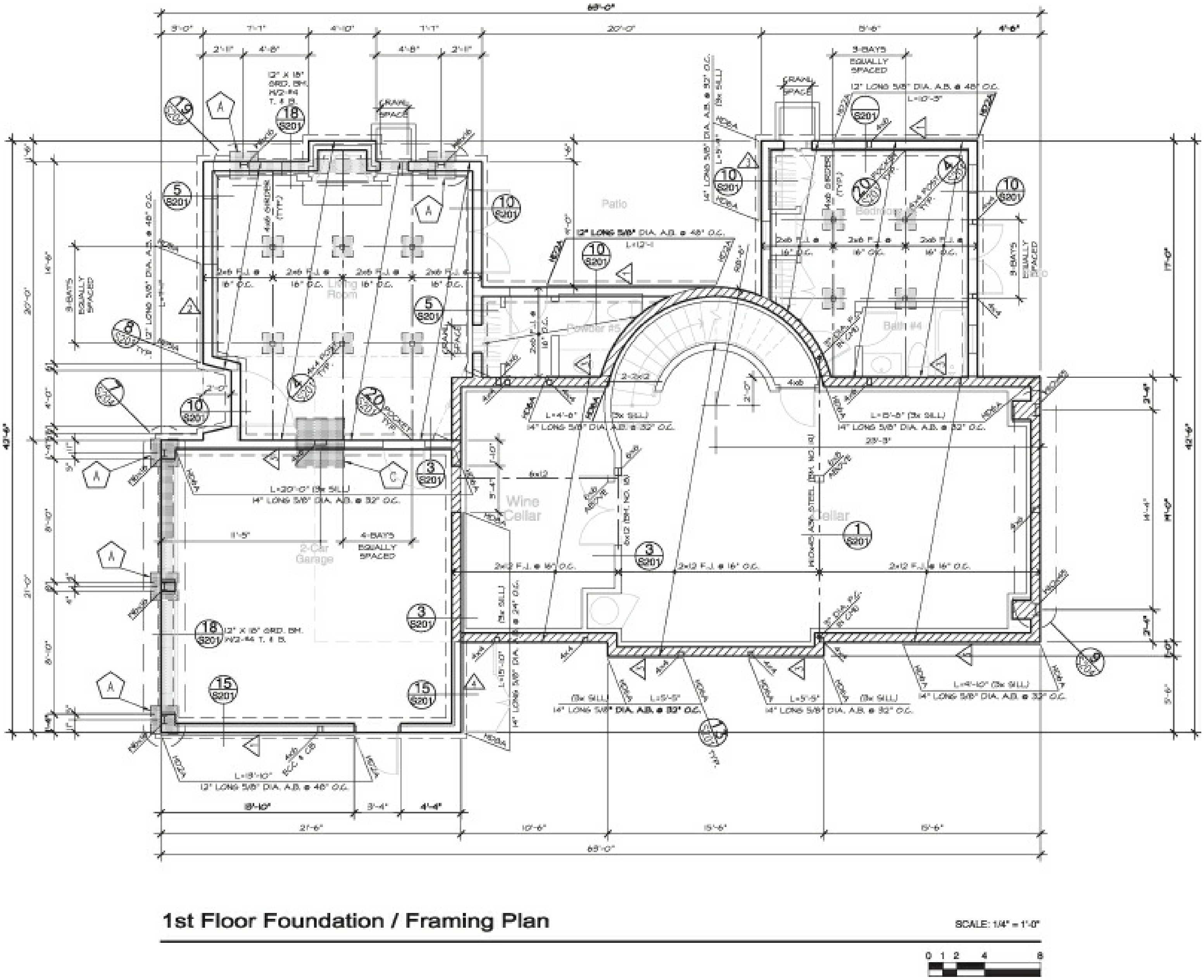
Figure 9.39 Stage IV: Steps, depressed slabs.

Stage V (Figure 9.40). Dimensioning takes place at this stage. Remember, the dimensions on the floor plan are to face of stud (FOS), and dimensions here should be the same as those on the foundation plan.



[Figure 9.40](#) Stage V: Dimensioning.

Stage VI ([Figure 9.41](#)). All noting takes place at this point, the final stage. Remember that main titles should conform to the standard office font, and all other noting should be done with an architectural lettering font that allows for easy manual correction.



[Figure 9.41](#) Stage VI: Noting, titles, and reference bubbles.

A STEEL STRUCTURE

The foundation plan for a steel building is presented in this section as an example of a foundation plan for a commercial building.

Stage I

For this all…steel building, all drawings were produced using the dimensional reference system (see [Figure 9.42](#)). Thus, the datum or base for the foundation plan is the matrix.

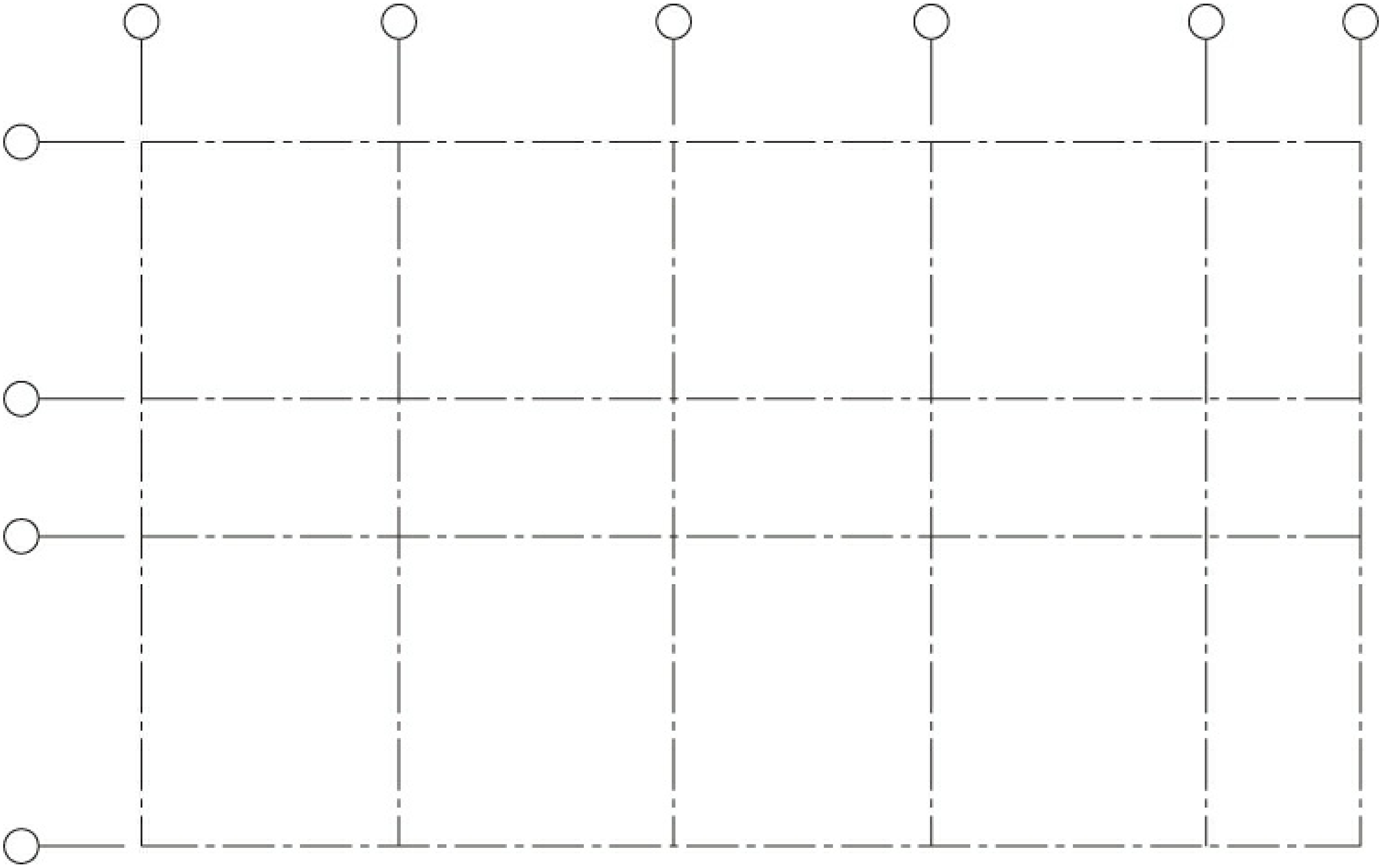


Figure 9.42 Stage I: Establishing datum.

Stage II

The structural engineer has established the size of the various concrete pads and pipe columns and provided us with engineering details (see Figure 9.43). These important pieces of information would be translated into a drawing in the next stage.

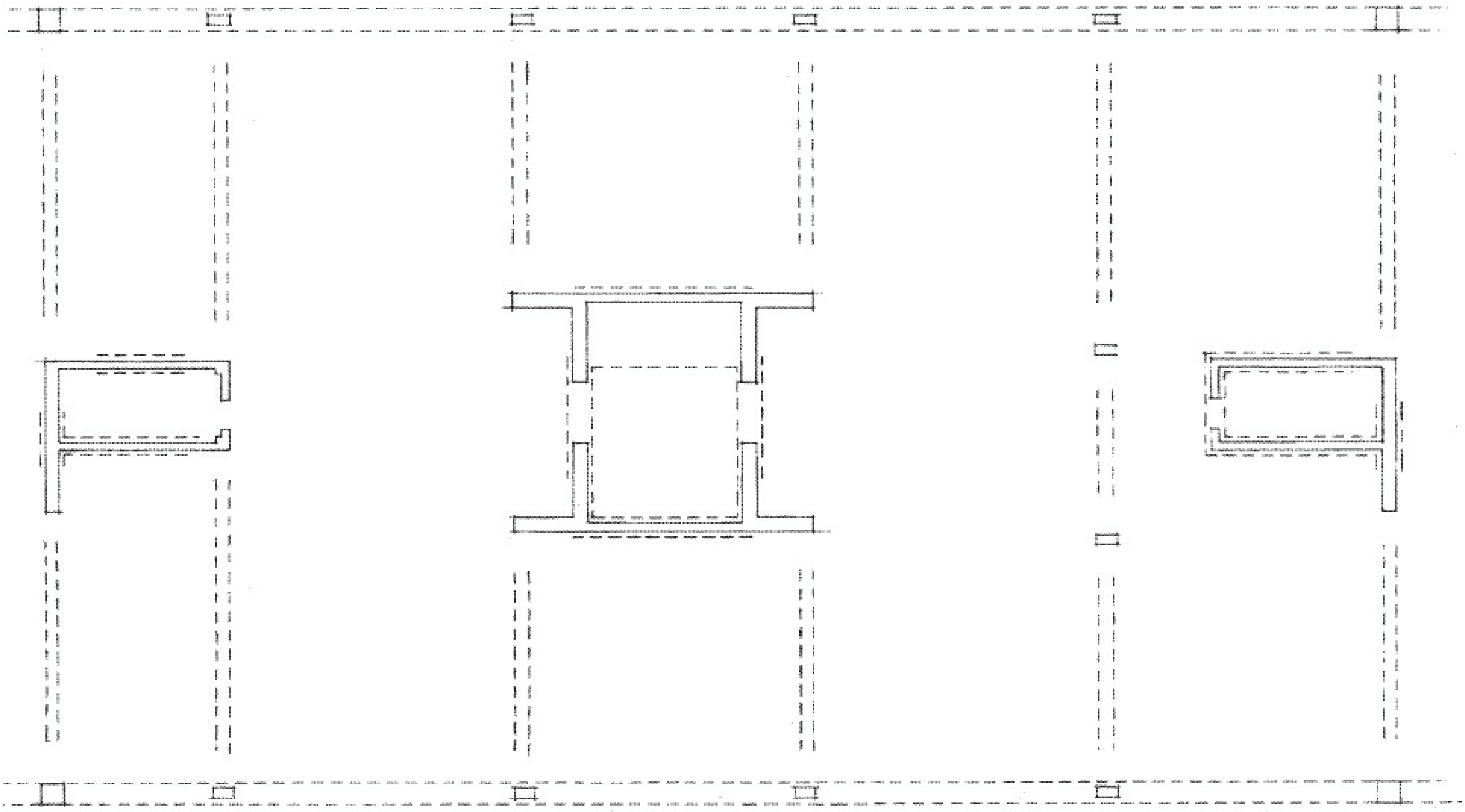


Figure 9.43 Foundation plan: Stage II.

Stage III

As you compare the beginning stages of the ground…level plan and the ground…floor plan, you will see differences at the stair area (see Figure 9.44). When the complete set of drawings was submitted for building department plan check, changes were made. We next drafted columns (circles) and their respective support pads (squares). We obtained their sizes and shapes from the structural engineer.

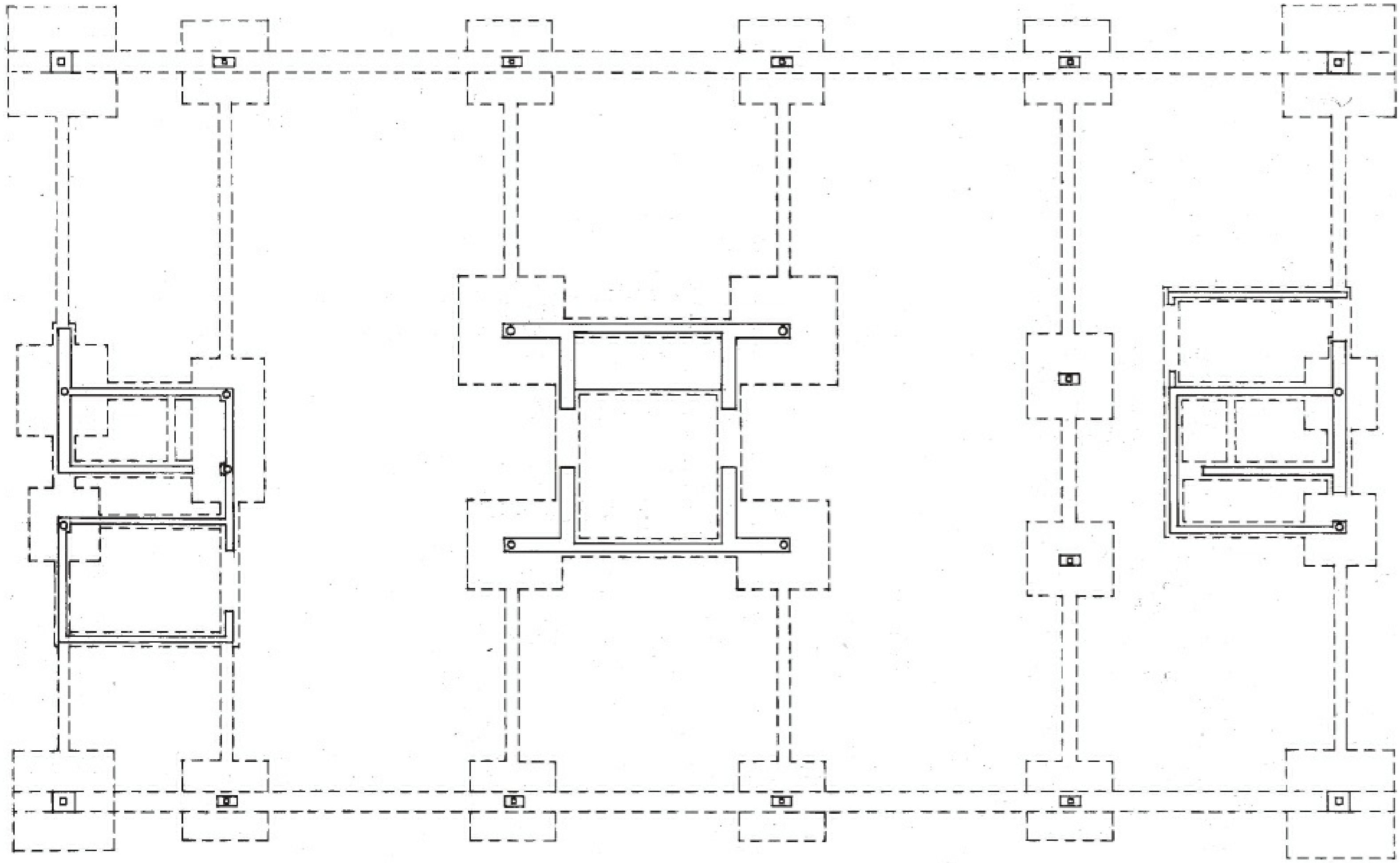


Figure 9.44 Foundation plan: Stage III.

Stage IV

Dimension lines were the first addition to the drawing at this stage. We used the reference plane system (see Figure 9.45). All subsequent dimensions were referenced to this basic set on the top and to the left. In the lobby area (central portion of the plan), where the walls do not align with the existing reference bubbles, we added new bubbles. We showed partial and full section designations.

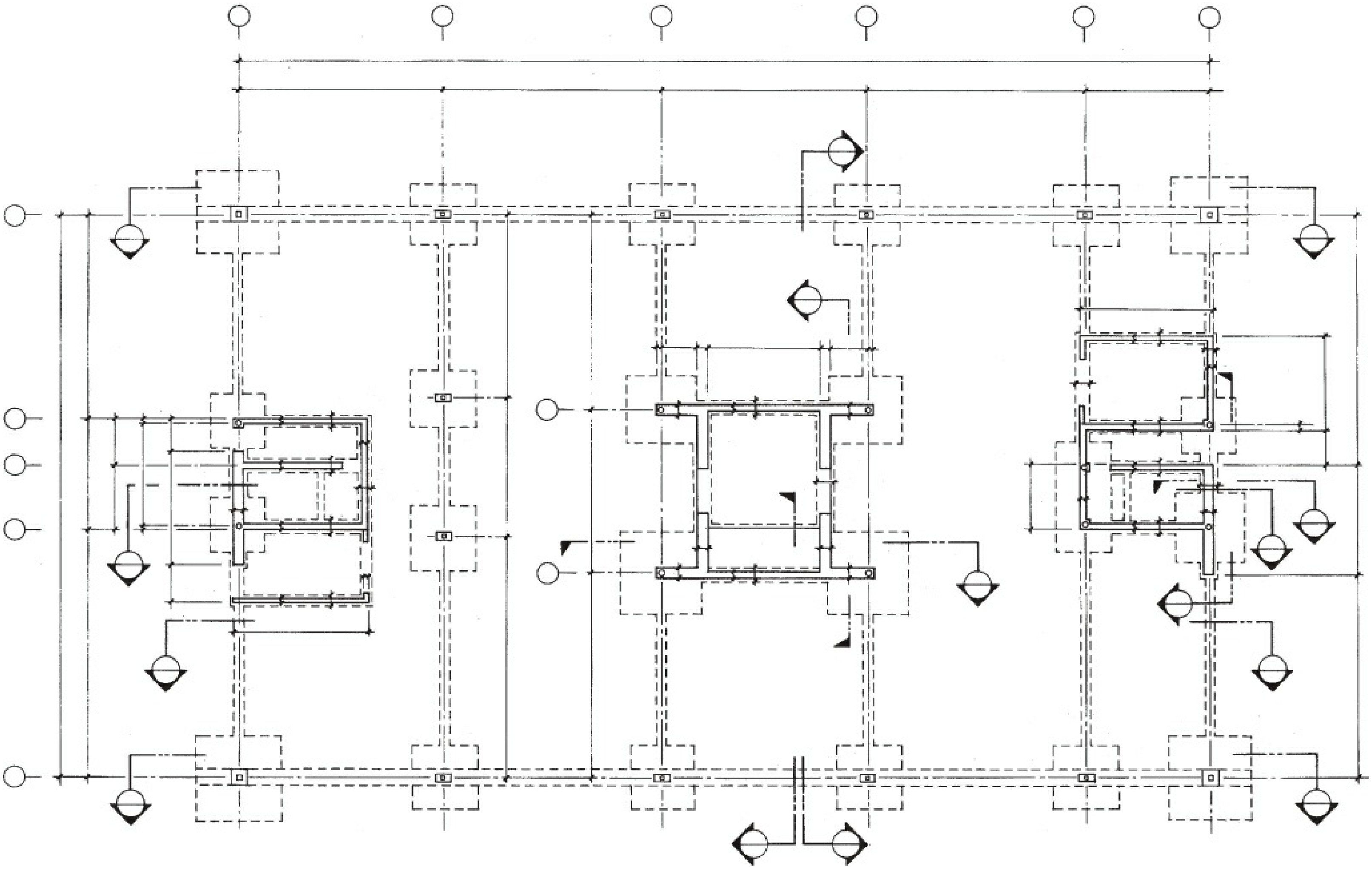


Figure 9.45 Foundation plan: Stage IV.

Stage V

Dimensions were added for the concrete…block foundation walls. We also dimensioned the width of all footings (see Figure 9.46). A single detail is used for all of the foundation walls and footings. The material designation for the concrete…block walls and variations in dimensions in the footing and width of the walls were added. Also, the section reference notations were filled in, using the section designation symbols.

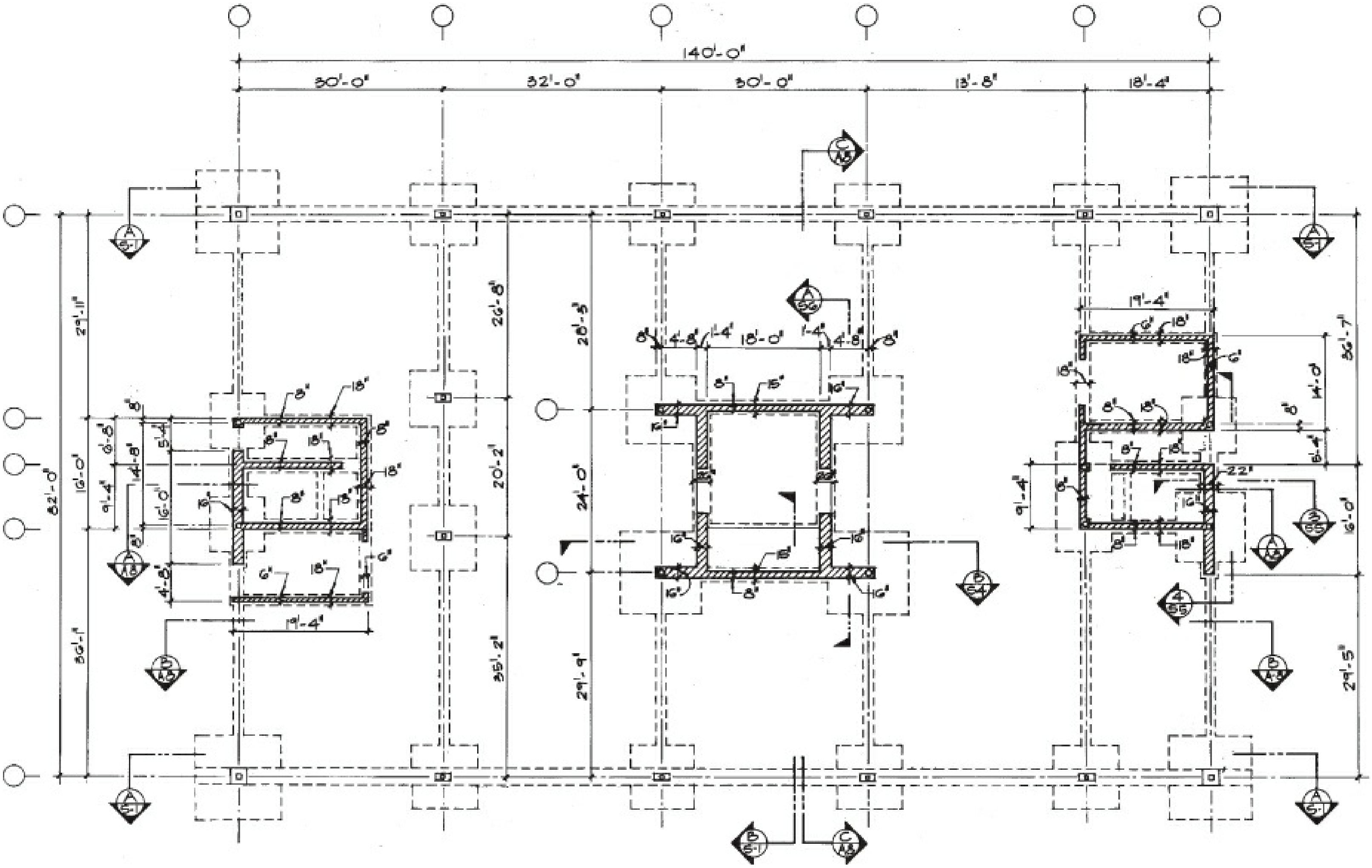
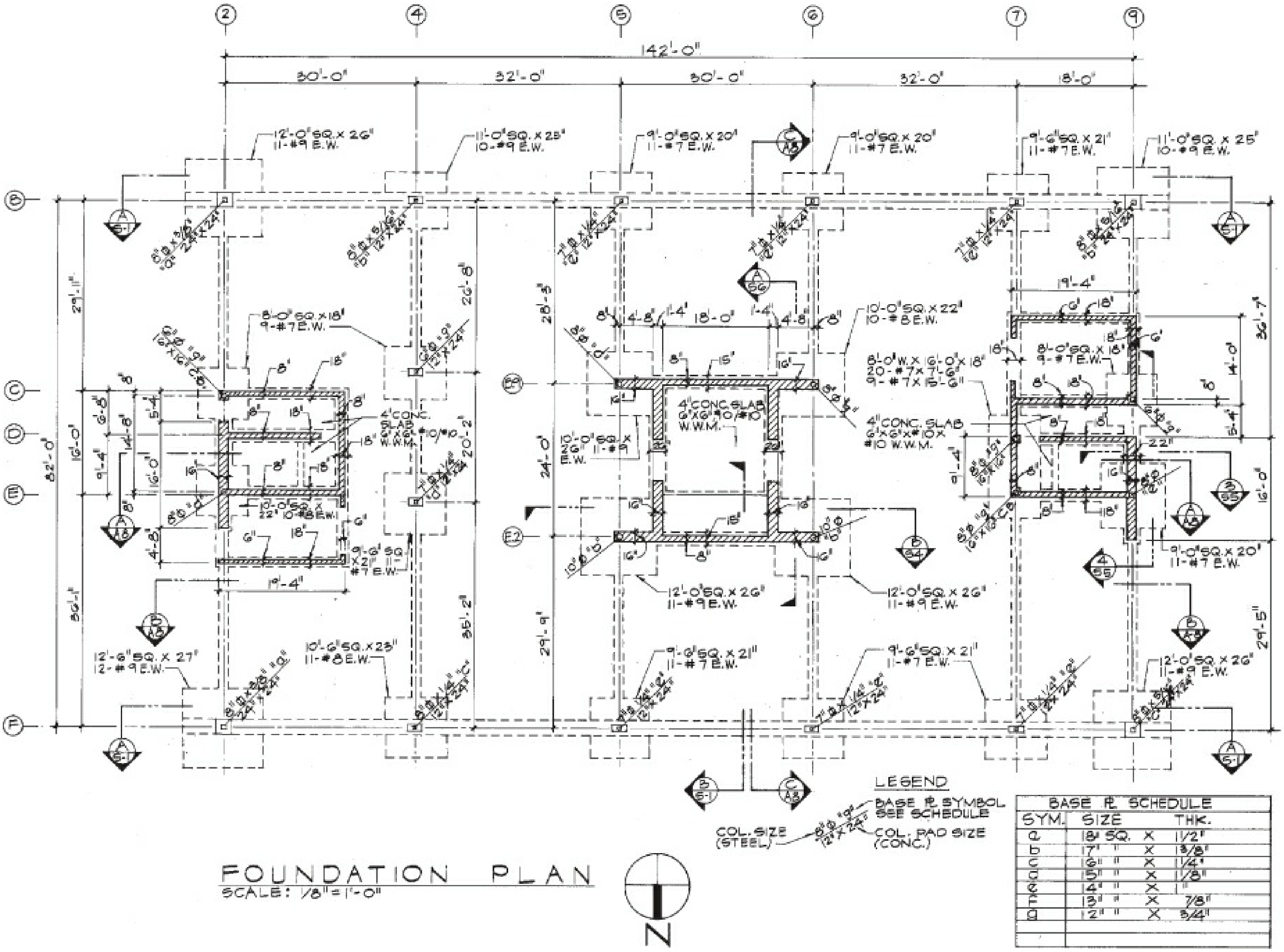


Figure 9.46 Foundation plan: Stage V.

Stage VI

At this stage we added all remaining numerical values and filled in the reference bubbles on the matrix in the dimensional reference system (see Figure 9.47). The reference B.9, for example, indicates that there is a column at an intermediate distance between B and C of the axial reference plane. B.9 is approximately 9/10 of the distance between B and C. If there were another column that was 8/10 of the way between B and C, it would be designated B.8.



[Figure 9.47](#) Foundation plan: Stage VI.

Around the perimeter of the structure is a series of squares drawn with dotted lines. These represent concrete pads that distribute the weight bearing down on the columns. The leader pointing to the hidden line indicates the size and thickness of the concrete pad and reinforcing.

At the center of these hidden lines is another rectangle with a smaller rectangle inside, representing a steel column. The leader pointing to this area explains these. For example, 7 × 7 × ¼, 12″ × 24″, means that the column is a 7″…square column, ¼;″ thick (wall thickness), mounted onto an “e” base plate. This “e” base plate size can be found in the base plate schedule at the lower right of [Figure 9.49](#). Here, “e” is equal to a 14″…square by 1″…thick plate. This plate rests on another concrete pad, often called a **pedestal**, 12″ by 24″ thick.

Contained within the masonry walls are some steel columns, with concrete pads that are also noted using the schedule. Next to the schedule is a legend explaining the noting method. The title and north arrow finished this sheet.

CASE STUDIES: WORKING DRAWING DEVELOPMENT

In this section, we discuss the development of the foundation plans working drawings for the Clay Theater steel and masonry building (Chapter 18), where the ground floor becomes the foundation plan.

Clay Theater—Steel/Masonry Structure

Foundation Plan. The floor plan is used as a base or datum when drawing the foundation plan (see Figure 9.54). Size and opening locations must conform to the block module.

Stage I. To better understand the evolution of this plan, see Figures 9.48 and 9.49. Both the aerial photograph and the ground level view show how the property is graded. Stakes were used to guide the large earth…moving equipment, as you can see in Figure 9.50. Figures 9.51 and 9.52 show the chalk lines indicating the position of the wall columns, and Figure 9.53 shows trenched footings. A **backhoe** (trenching machine) was then used to dig the required trenches.

Figure 9.48 Graded site without structure.

Figure 9.49 Grading the property.

Figure 9.50 Stakes placed by surveyor.

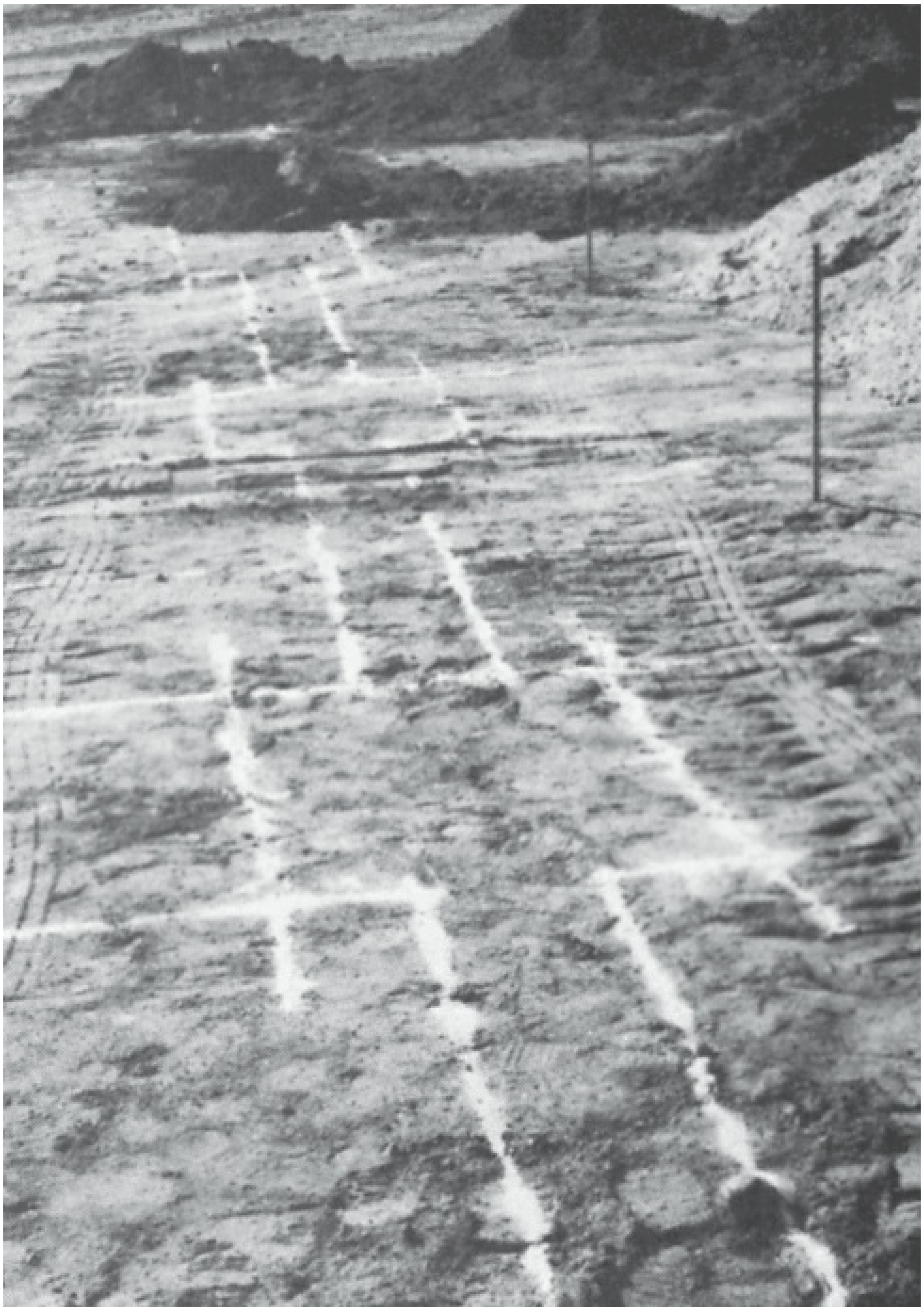


Figure 9.51 Chalk lines for foundation.

Figure 9.52 Chalked lines ready for trenching.

Figure 9.53 Trenched footing.

Pilasters (periodic widening of a wall) act as columns to support members above. On interior walls, pilasters are seen from either room, while exterior pilasters can be seen only from the inside, so that the face of the exterior wall can remain flat. Pilaster sizes are obtained from the structural drawing; a few typical sizes are used. If you start a foundation drawing before you have these required sizes, you can still trace the walls and indicate the tentative location of the columns and pilasters with light cross lines to show the center. Figure 9.54 shows the first stage in the preparation of the foundation plan. In this drawing, lines are dotted lines, but often, at this initial stage, the outline is drawn with light solid lines. Four lines are needed to represent the walls of concrete block and the footing below the grade. At some locations, where the footing is continuous but the wall is not, there are only two lines. The squares drawn with dotted lines represent concrete pads for steel pipe columns. The exit doors at the rear of each auditorium are interesting features of this project. Each exit was designed to be sheltered by a wall with a

trellis above. The rectangular areas adjacent to the easterly side are ramps for handicapped persons. (Every feature of this theater had to accommodate persons with disabilities. These features include restroom facilities, widths of openings and halls, and ramps for wheelchairs.) The columns toward the center of the structure would hold up the upper floor. Figure 9.55 shows these columns and also the forms placed for the entry stairs adjacent to the ramps for disabled persons. The columns were carefully aligned with the upper…floor walls and first…floor walls.

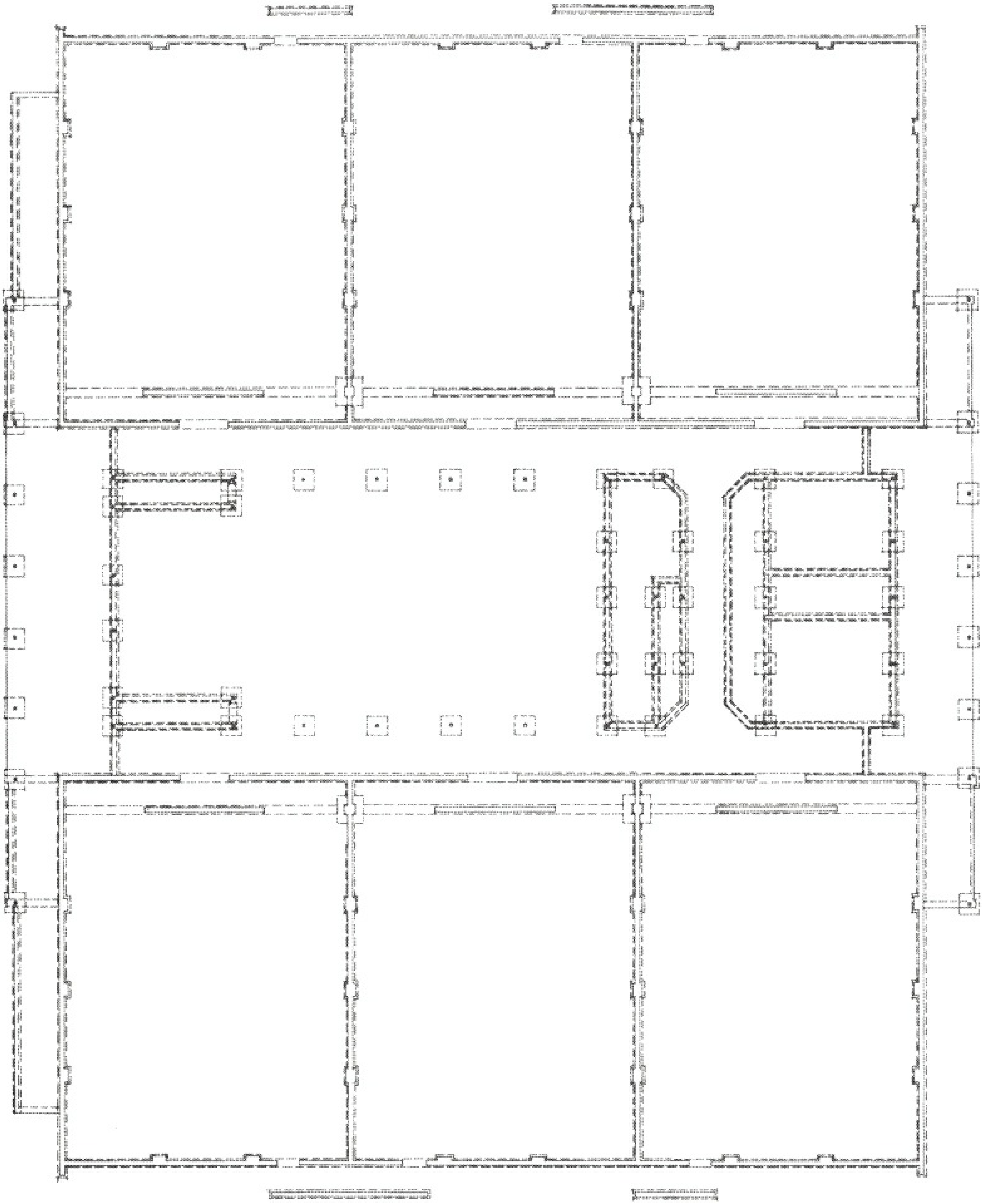


Figure 9.54 Theater—Stage I: Working drawing—foundation plan.

Figure 9.55 Clay Theater—columns support.

Stage II. The inclusion of the stairs in Figure 9.56 clearly identifies the entry to the theater. The two lines extending from each column with several perpendicular lines in them represent **brick pavers** (patterned brick on ground level).The arc lines within one of the auditoriums represent the subtle changes of levels. This was done only once because the floors in all six auditoriums are the same. All exterior and interior dimension lines were added next, taking care to ensure a proper block module. The reference bubbles on the outside of the overall dimension lines are called, collectively, a matrix of the dimensional reference plane. This matrix is used to locate columns, walls, and structural members above (not seen in this drawing).

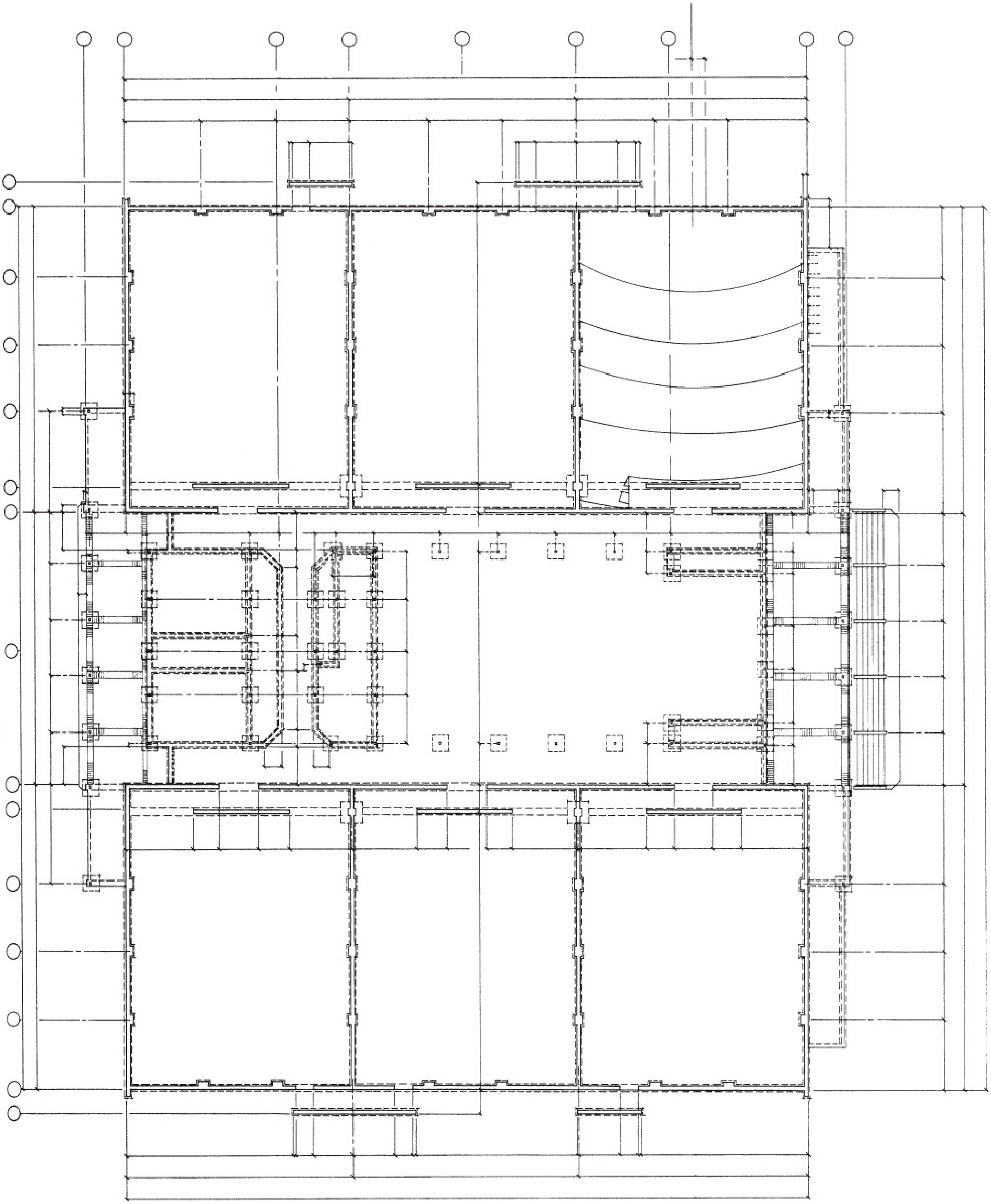


Figure 9.56 Clay Theater—Stage II: Working drawing—foundation plan.

Stage III. Major section lines were added at this stage, as were detail reference bubbles.

See Figure 9.57. Some of the section symbols break the overall dimension lines. This is not desirable, but we had to do it because of space limitations. At the top right auditorium (looking at the building from the side where the entry is), notice two reference bubbles piggybacked. This indicates that two details of these columns are available elsewhere, one architectural and the other a structural detail. The section bubbles with a flag…like symbol on the opposite side indicate wall sections. In the lobby, next to the columns, are hexagonal symbols. These are concrete pad symbols and will have numbers or letters in them corresponding to the chart introduced at the bottom right. Each concrete pad for the various columns varied enough to necessitate a chart rather than individual dimensions. We finally added the material designation for the walls (the hatching lines within the wall lines).

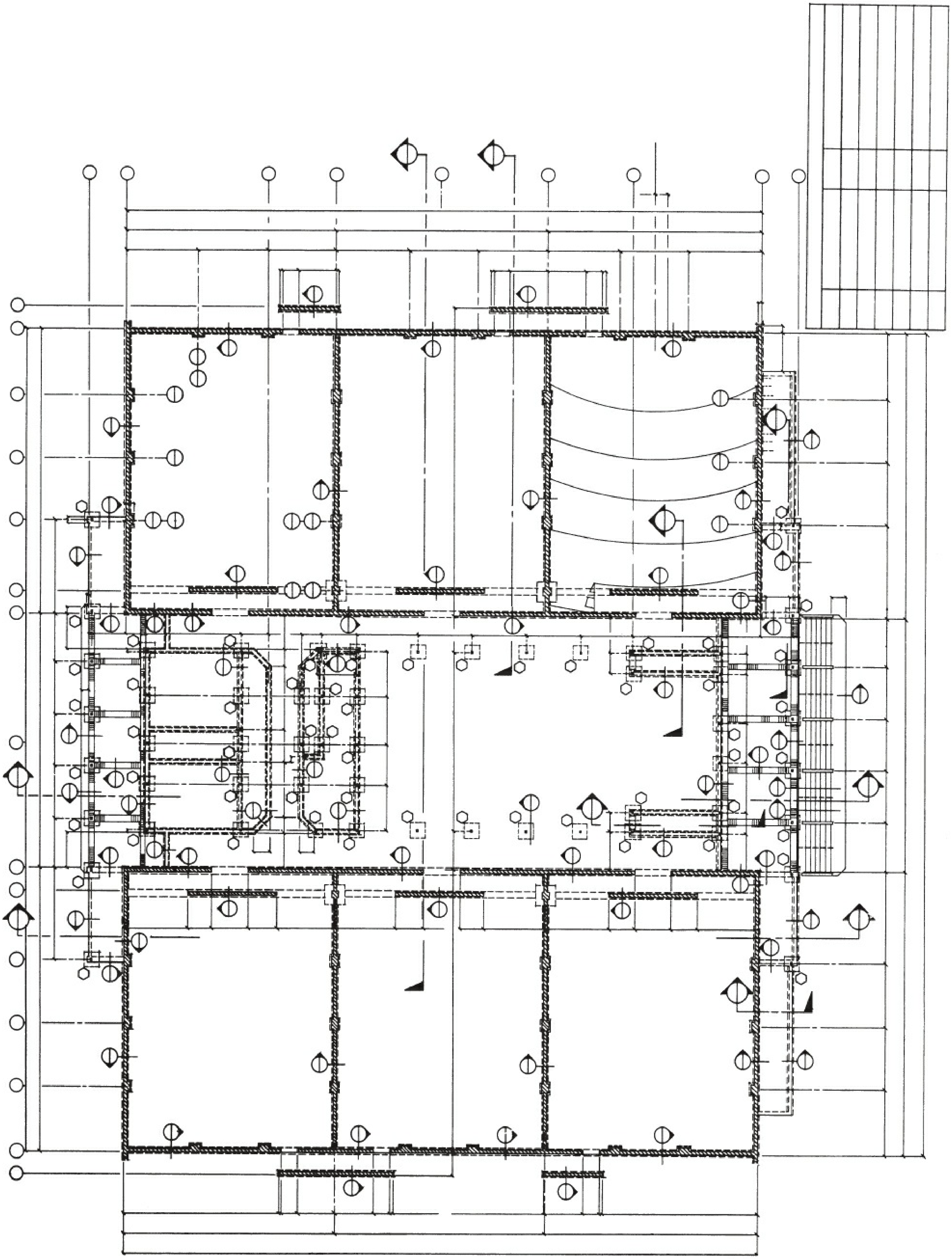
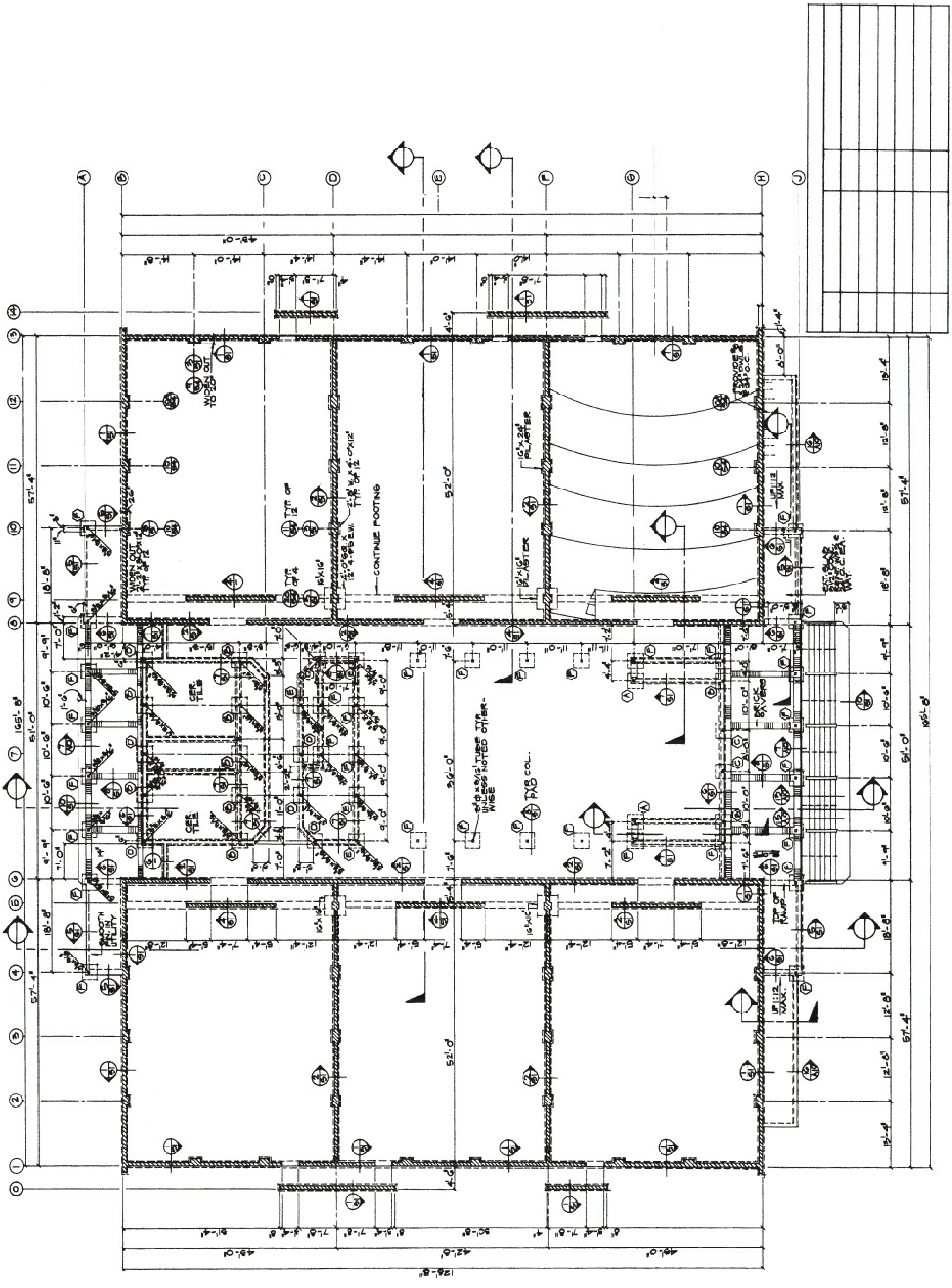


Figure 9.57 Clay Theater—Stage III: Working drawing—foundation plan.

Stage IV. Noting, referencing, and actual numerical values of dimensions were now added. See Figure 9.58B. Noting included describing the floor material, such as the ceramic tile in the restrooms and brick pavers at the front of the theater. We indicated slopes on the ramps for the disabled. We noted special widening instructions along the perimeter of the foundation wall as well as sizing of the pilasters. At the center of the structure around the concession stand, a note reads “3” × 3⁄16″ tube typ. Unless noted otherwise.” Many of the columns at the rear of the concession stand and around the restroom area have a diagonal line indicating a different size. Numerical values were placed, each being checked to ensure that the overall dimension fell within the block module. Some of the values are missing near the schedule at the bottom. These dimensions are picked up later. All of the detail and section reference bubbles were noted, and the axial reference planes (the numbers across the top and the letters along the right side) were finished. For the final stage of the foundation plan, please see Figure 18.9.



CER. TILE
BRICK PAVERS
CONTINUE FOOTING
TOP OF RAMP
52'-0"
57'-4"
51'-0"
165'-8"
126'-8"

Figure 9.58 Clay Theater—Stage IV: Working drawing—foundation plan.

ROOF PLANS AND FRAMING SYSTEMS

Methods of Representation

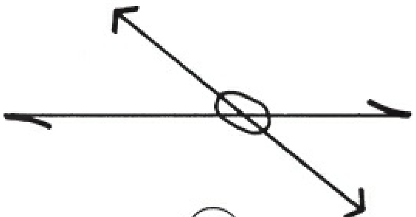
There are two main ways to represent floor, ceiling, and roof framing members as part of construction documents: drawing framing members on the floor plan or drawing them separately.

Roof Framing Systems

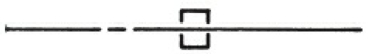
As you look at the various framing plans, you may see many conventions that require clarification. For this reason, we have included a chart of typical conventions in Figure 9.59. You may find it helpful to flag this chart as you look at the various framing plans and use it as you would a dictionary, that is, as a reference table that defines the conventions used.

A

B

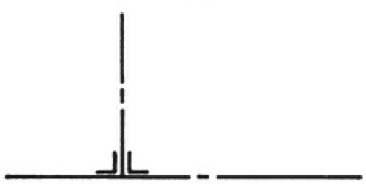


C

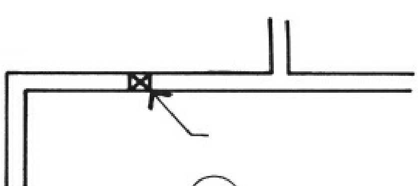


D

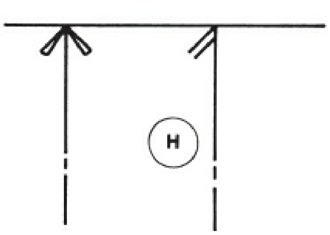
E



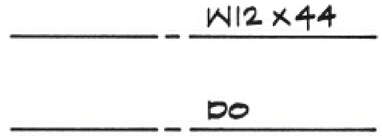
F



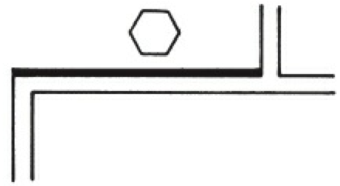
G



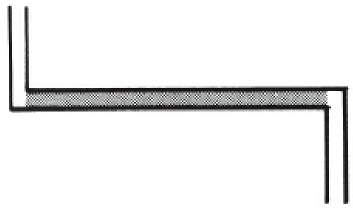
H



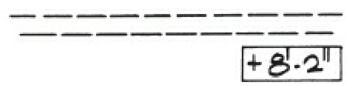
I



J

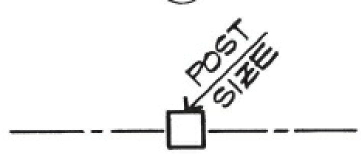


K

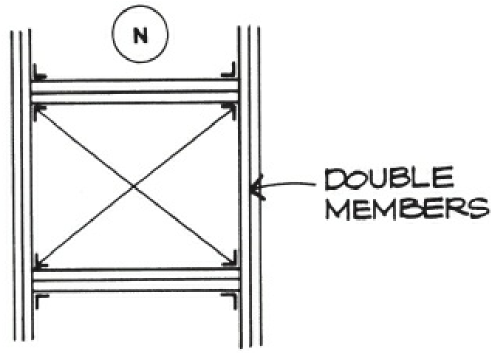


L

M



N



O

Figure 9.59 Summary of typical framing conventions.

A. A beam, header, or lintel over an opening, door, or window within a wall. Takes a call…out, such as "BM #2 4 × 10 HDR, DF #1."

B. Used to show the direction of a framing member or a system of framing members, such as floor joists, rafters, or ceiling joists. Lettering occurs right along the line, indicating size, name, and spacing; for example, "2 × 6 ceiling joist at 16″ o.c." Note that a half arrowhead is on one side and another half on the opposite side.

C. The line with the half arrowheads is the same as described in definition B. The diagonal line with a full arrowhead on both ends indicates the duration of the system, for example, where a particular system of ceiling joists begins and ends. When sizes of the ceiling joists vary in length or size, this symbol is used to convey to the contractor what size framing member to use and where.

D. A beam, girder, or joist over a post.

E. A beam, girder, or joist under and supporting a post.

F. The employment of a framing anchor or joist hanger at the intersection of two members.

G. A structural post within a wall.

H. Two framing systems on the drawing. For example, one might represent ceiling joists, and the other roof rafters.

I. "W12 × 44" is a call…out for a steel beam or girder. When these members are sequentially repeated, the centerlines are still drawn to represent them, but the description (call…out) is abbreviated with the letters DO, which is short for "ditto."

J. In using conventional wood framing, which is subject to lateral forces such as wind and seismic, a plywood membrane is often placed on all or a portion of the complete wall surface. An adjacent triangle symbol refers readers to a nailing schedule to ensure minimums for nails to secure the plywood to the studs. These are called shear walls or shear panels.

K. An alternative way to demonstrate shear walls.

L. The rectilinear box that contains the 8′…2″ dimension is a convention used to indicate height of an object in plan view. The two dashed lines may represent the top of a beam or the plate line at a wall.

M. The use of three lines, instead of two, represents a double joist at the partition.

N. A post on top of a beam; similar to E, but with a post size notation.

O. An opening in a floor, ceiling, or roof system. The two lines surrounding the opening represent the doubling of the joists, and the dark L…shape indicates the use of framing anchors or hangers. The large X is the area of the opening. This convention is used for skylights and openings in the ceiling or roof for chimneys, a hatch, or attic access.

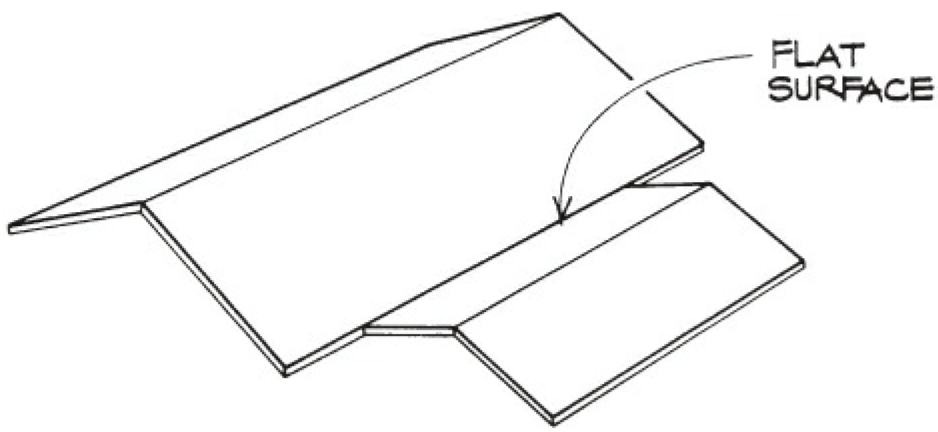
Roof Plan

A roof plan is a simple look at the top view of a structure, as if you were aboard a helicopter. Unless you are looking at a flat roof, the view is usually distorted, because a roof plan cannot reveal the entire surface of the roof in its true shape and size if there are slopes involved.

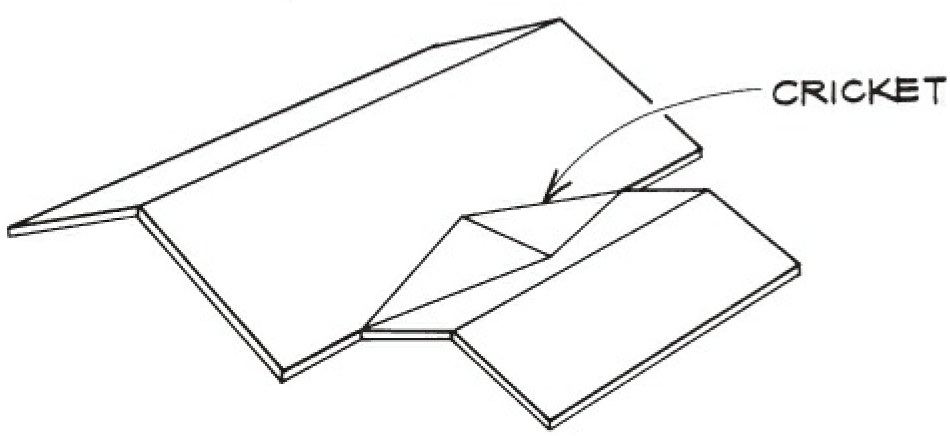
There are a multitude of roof forms. Among the most commonly known are flat parapet, gable, hip, and shed roofs.

Most small structures, especially residential structures, use a flat, gable, or hip roof; the determination of roof type is influenced by the prevailing rain or snowfall. Throughout this section, we will devote most of our attention to the hip roof. If you can configure a hip roof, a gable or flat roof will be a simple task.

Our approach will be to create a roof system that is geometrically correct and consistent in pitch, while avoiding flat areas that can entrap rain, thus causing leaks through the roof structure. Note the roof structure in Figure 9.60. Between the two roof systems, you will notice a flat (parallel to the ground) line. This space can trap water, causing deterioration of the roof material and, eventually, leaks. A short…term solution is to place a triangular metal form to induce the water to travel outward. Figure 9.61 shows a standard solution for a roof that was configured incorrectly to begin with. See Figure 9.51 for the geometrically correct way to solve the problem in this roof outline.



A



B

Figure 9.60 Incorrectly configured roof.

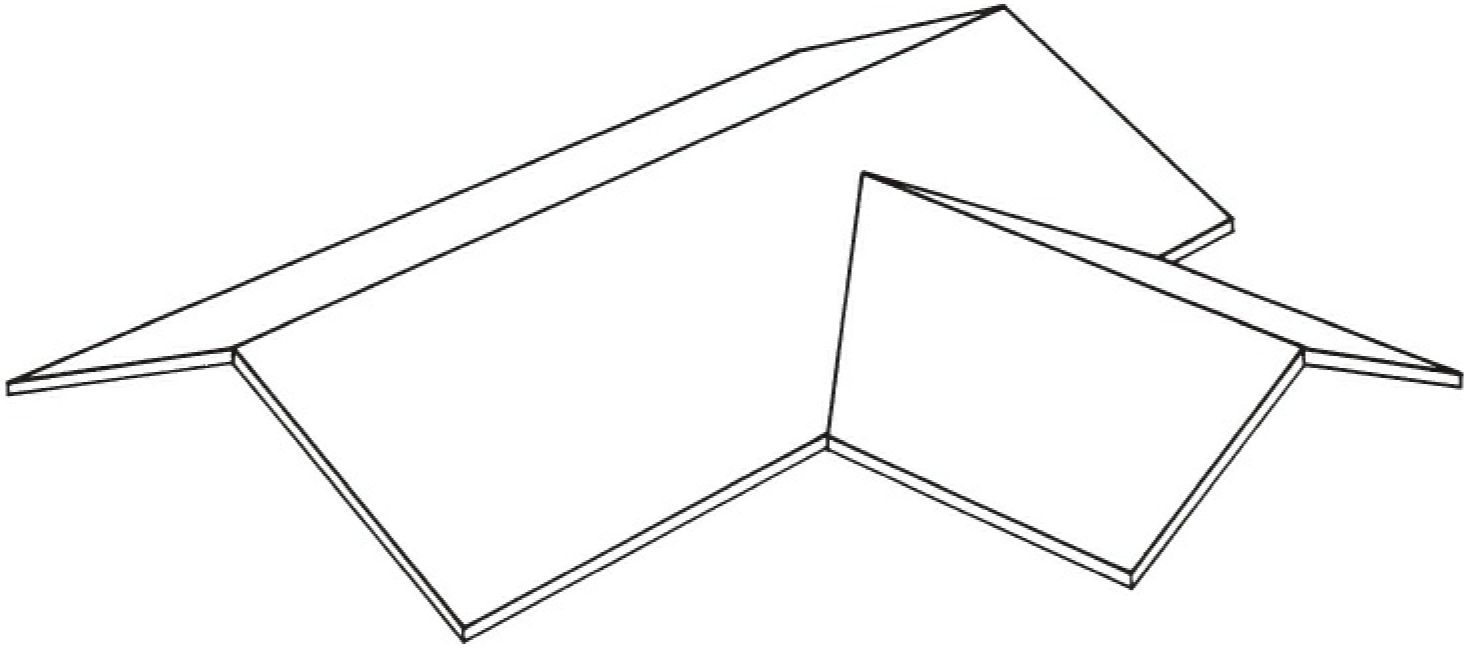


Figure 9.61 Ideal solution to avoid water problems.

We describe here the procedure you should follow for even the simplest of roof outlines. With this knowledge, you will be able to create even the most complex outline. Once you know the system, you may even alter the building configuration slightly to avoid problematic roof areas in your plan.

Solution to Problem 1

Step I Identify the perimeter of the roof as shown in the plan view in Figure 9.62. Be sure to dimension the overhang.

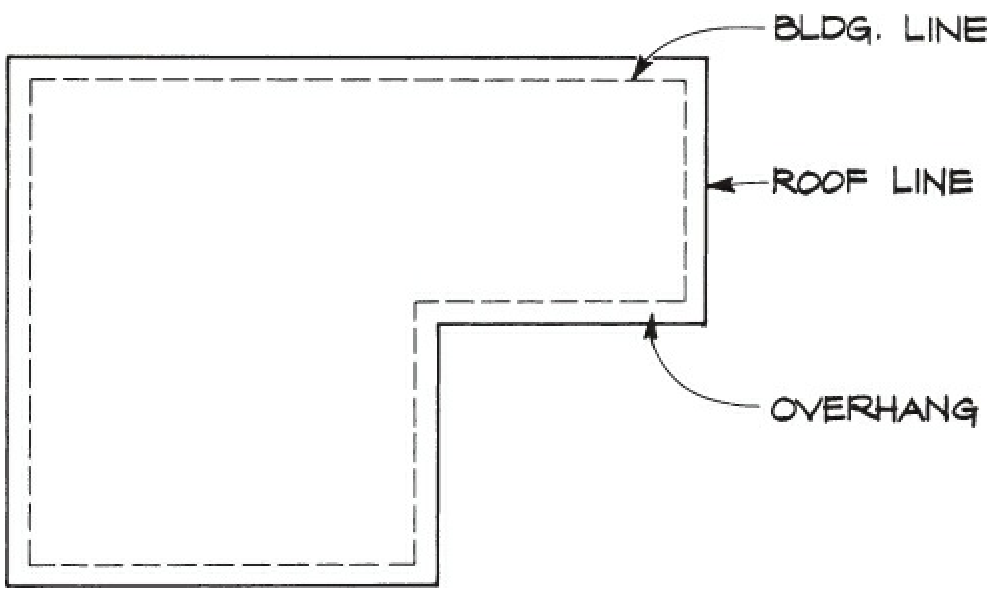


Figure 9.62 Draft the perimeter of the roof to be configured.

Step II Reduce the shape to rectilinear zones. Find the largest rectilinear shape that will fit into the roof configuration. Figure 9.63A shows an outline of a roof, and Figure 9.63B shows the selection of the major area, as designated by the number "1." The major area is not selected according to square footage, but by greatest width. Look at

another shape, similar to the preceding outline, in Figure 9.64A. Because the dimension of the base designated by the letter "B" is larger than base A, the major zone is zone 1, as shown in Figure 9.64B.

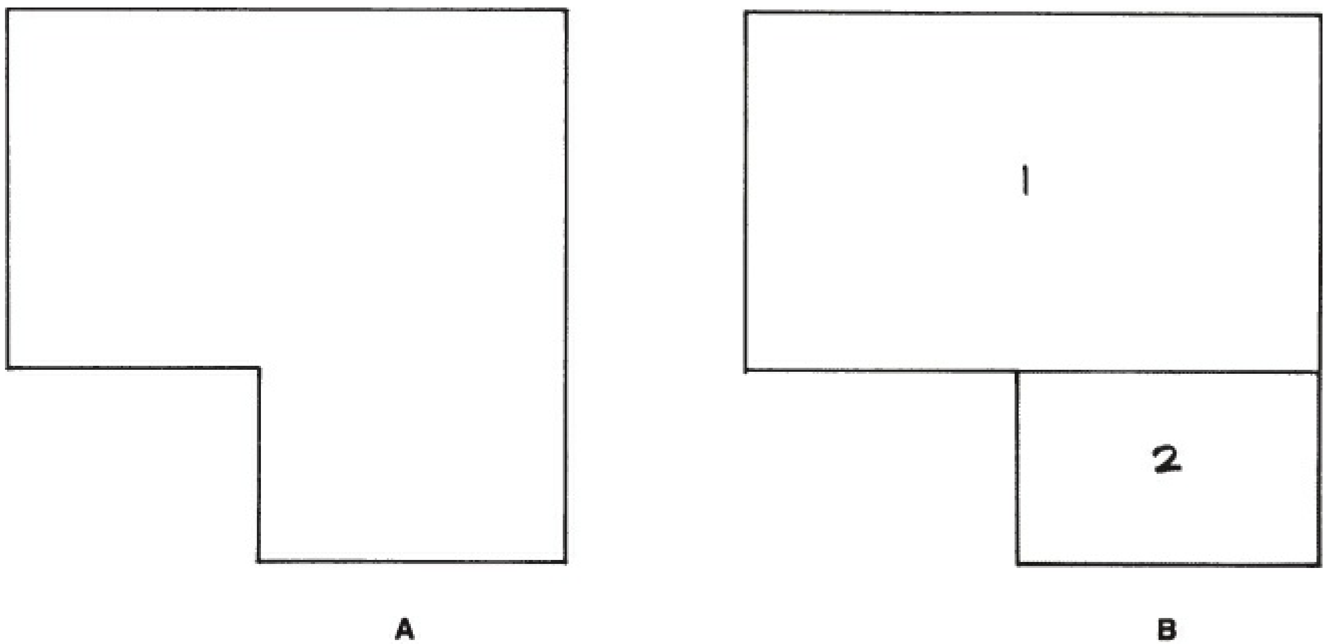


Figure 9.63 Find the major zone.

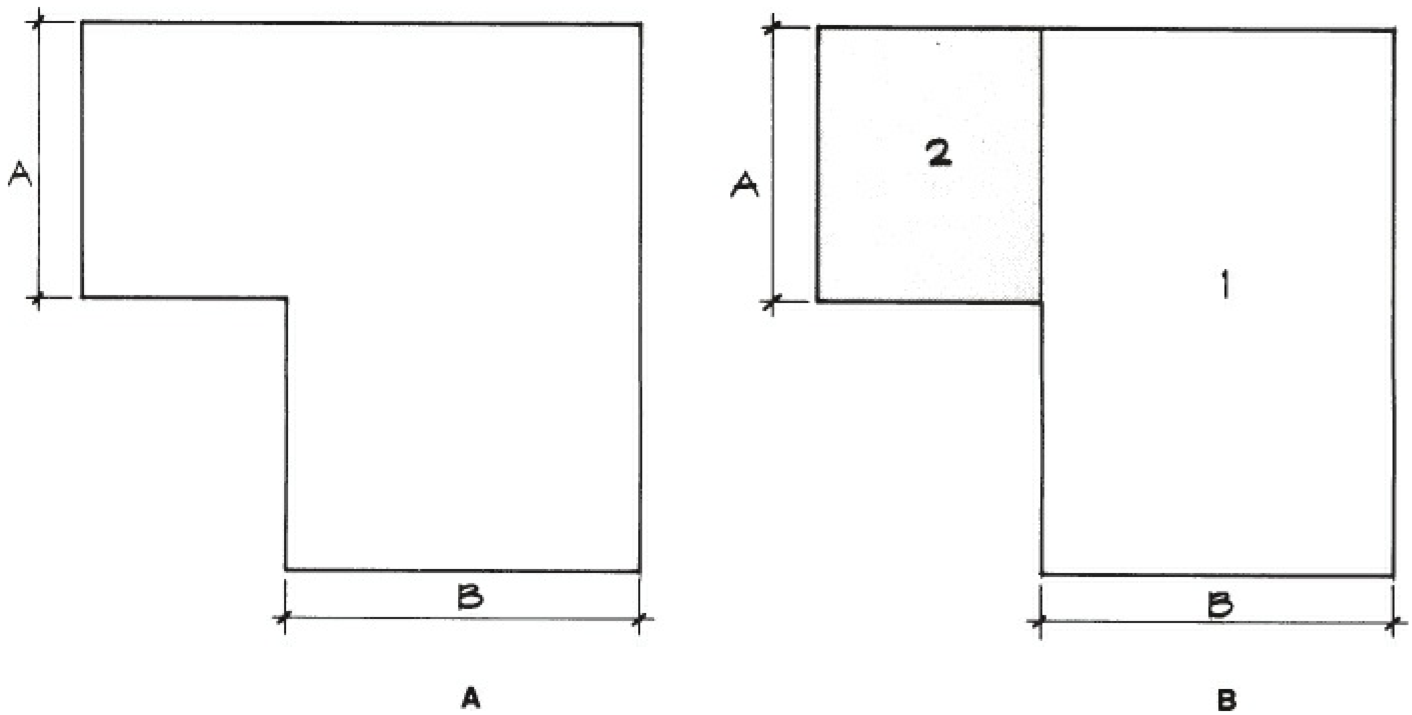
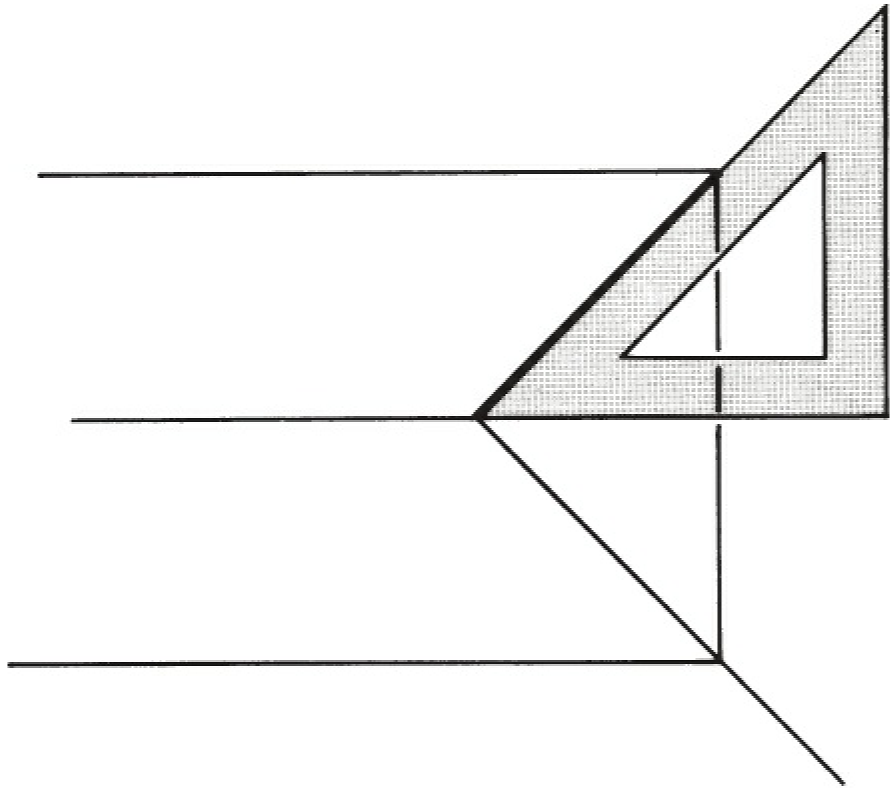
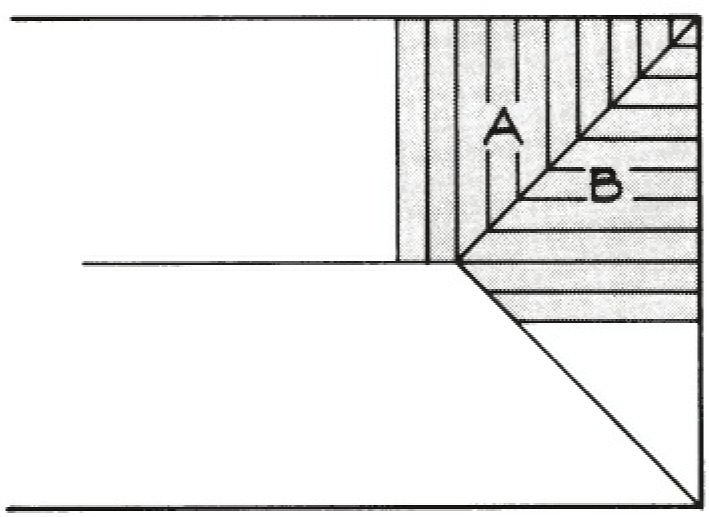


Figure 9.64 Letting the largest width determine the major zone.

Step III Locate both the hip rafter and the ridge. See Figure 9.65A. A 45° triangle is used to ensure the same pitch (angle of roof) on both sides of the roof, as shown in Figure 9.65B. This is possible when the corners are at 90° to each other.



A



B

[Figure 9.65](#) Use of 45° triangle to maintain pitch.

Note, in [Figure 9.66](#), that the outline has been organized into three zones: the main zone (1) in the center, with zones 2 and 3 above and below. These angles have been identified by the letters “A,” “B,” and “C.” For the sake of this solution, any angle such as A, which is 90°, will be called an inside corner. The other two corners (nos. 2 and 3) have angles greater than 90° and are referred to as *outside* corners.

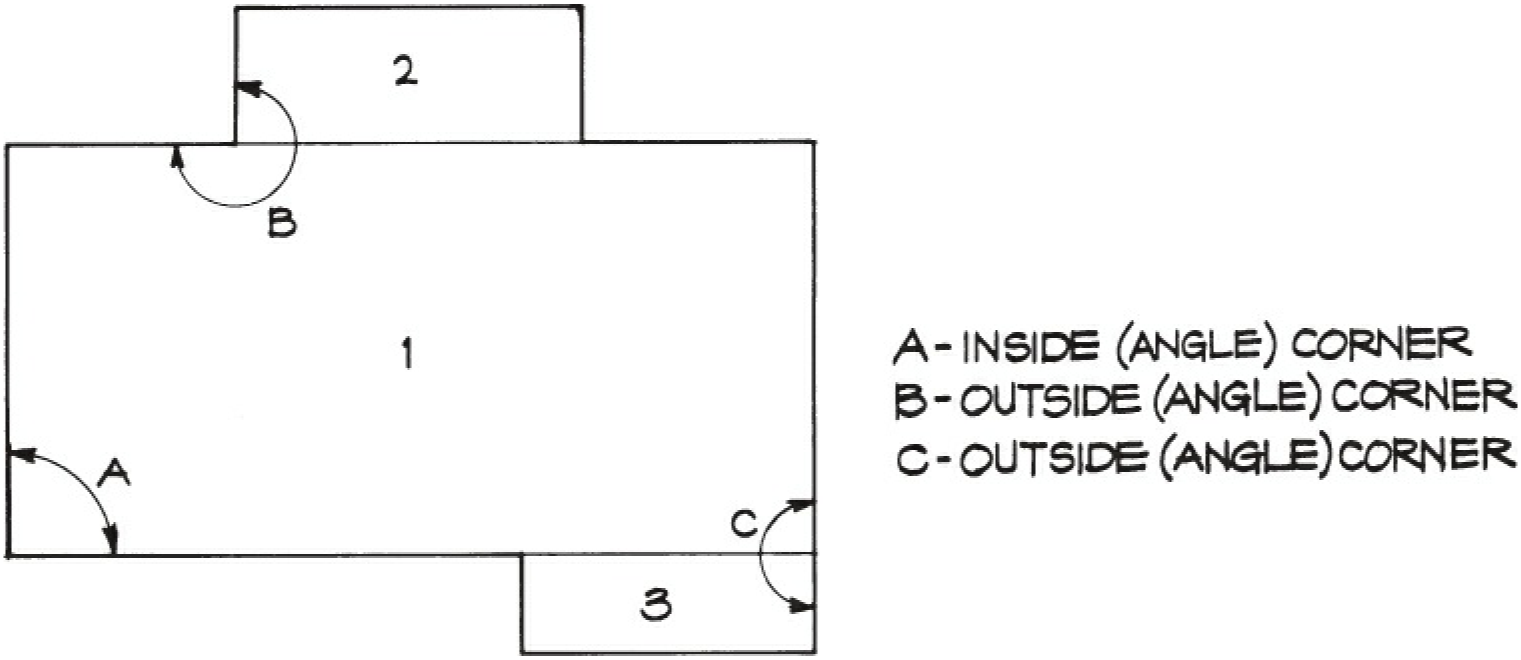


Figure 9.66 Defining inside and outside corners.

Step IV Configure the roof. Let us take this configuration and develop it into a hip roof with the information already learned.

Taking the major zone identified as zone 1 in Figure 9.67A, we strike 45° hip lines from each of the inside corners to form the main structure around which the other two zones will appear.

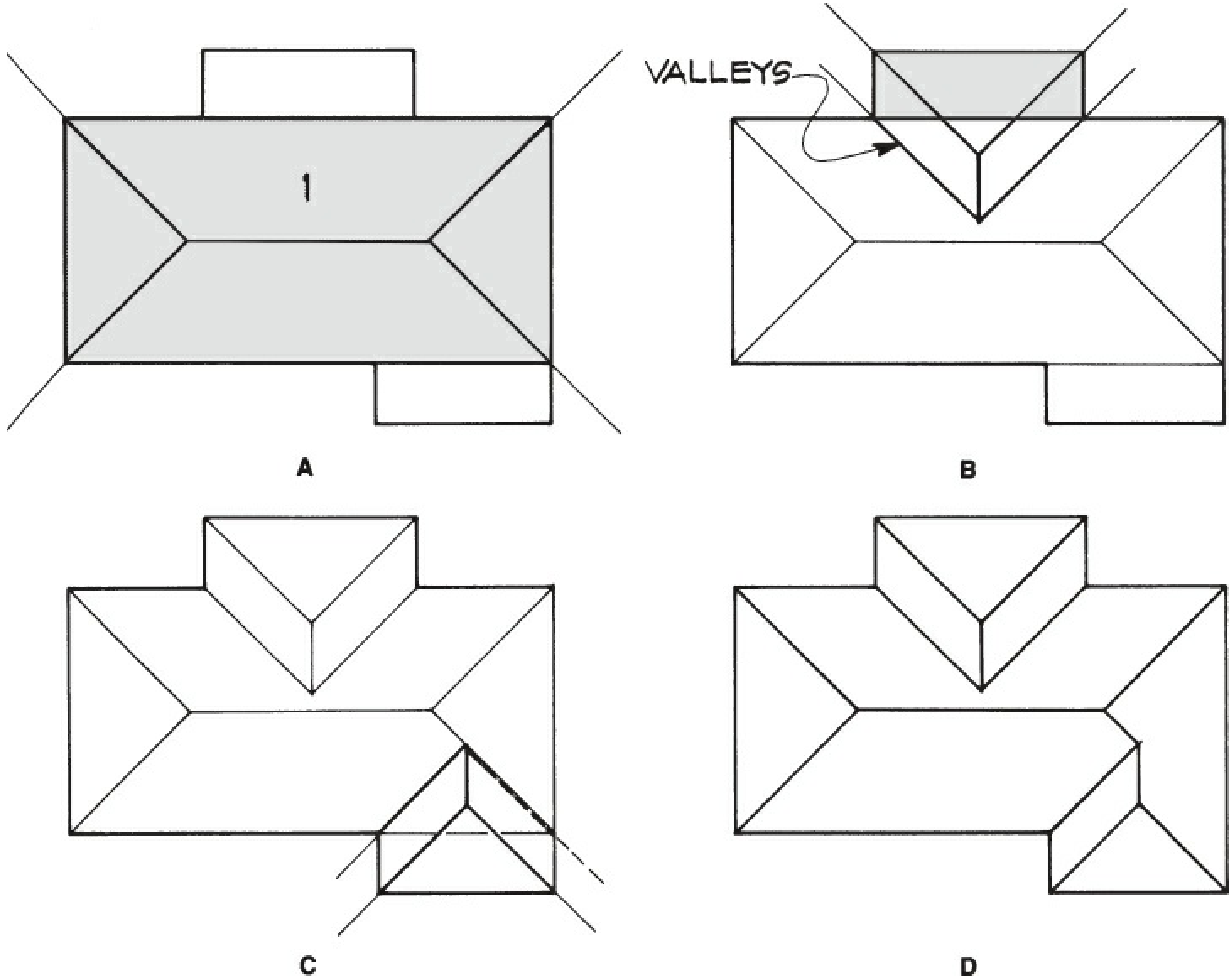


Figure 9.67 Solving hip roof Problem 1.

We now approach zone 2 in Figure 9.67B with an eye out for inside and outside corners. There are two of each. The inside corners at the top are drawn toward the center of the rectangle. The outside corners have their 45° lines going away from the zone 2 rectangle, thus forming the valleys of the roof.

The same approach is used for zone 3 as was used for zone 2. In the process of drawing the outside corners, you will notice that the one on the right overlaps an existing line (see Figure 9.67C). When this happens, the lines cancel each other, creating a continuous plane. See Figure 9.67D, which displays the final roof shape.

As you look at the final roof form, it may appear foolish to have gone through such an elaborate system because you may have been able to visualize the finished roof from the beginning. Let's reinforce and validate the procedure by attempting roofs of varying complexities.

Solution to Problem 2

Step I Figure 9.68A displays an area in the center that appears to be the major zone. By square footage, it might be, but remember, the major zone is the zone with the

greatest width.

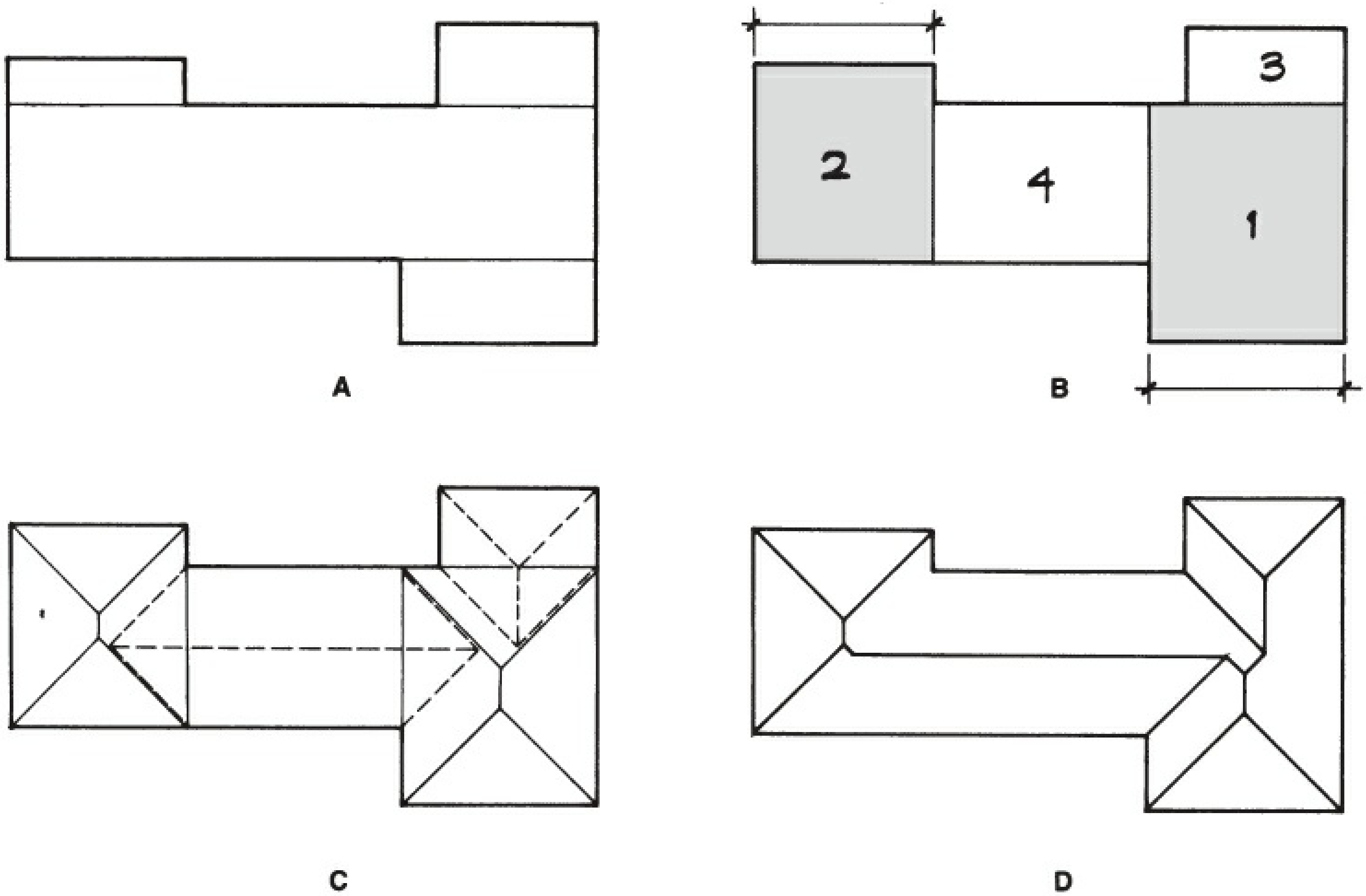


Figure 9.68 Problem 2.

Step II In Figure 9.68B, notice the relocation of the major zone by greatest width. Compare zone 1 with zone 2. The one with the greatest width will produce the highest ridge because it takes longer rafters in the framing of this roof.

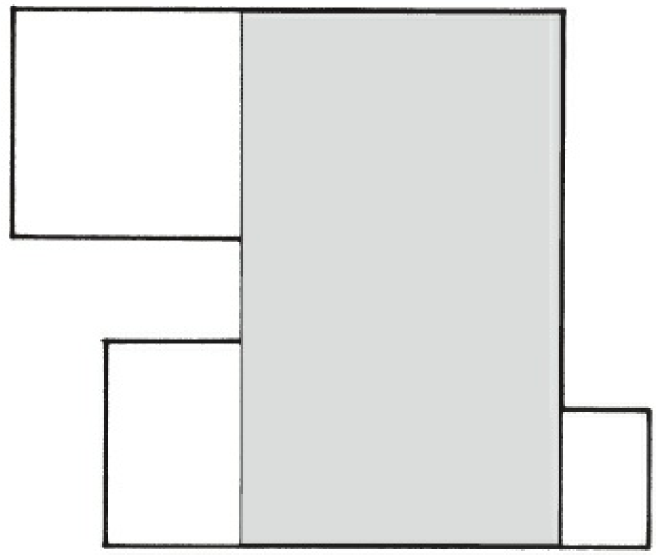
Step III Figure 9.68C shows all of the zones with roofs outlined. Remember the outside/inside corner rule.

Step IV As can be seen in the previous step, many of the lines overlap. In Figure 9.68D, we show them side by side for ease of understanding, but in reality they are on top of each other. This means they cancel each other and are erased.

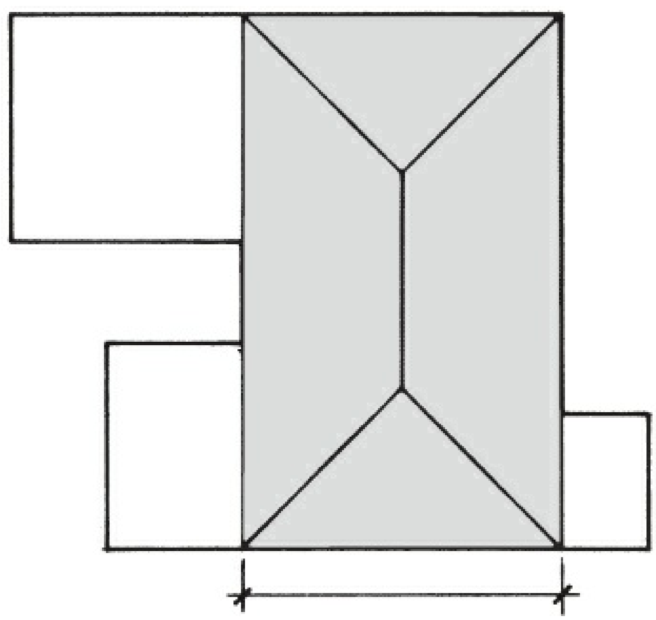
To continue this exploration of problems, we have selected an outline in which the major roof configuration will all but disappear as we develop the roof.

Solution to Problem 3

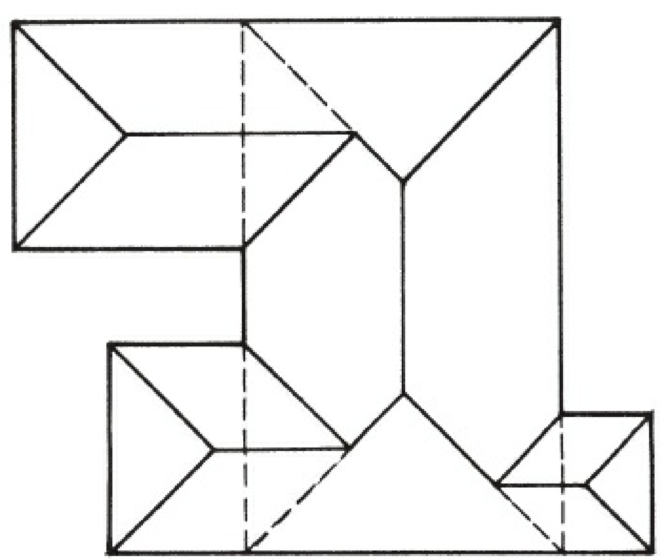
Step I In Figure 9.69A, the main zone is situated vertically through the center of the total form. Check this area, in width, with a horizontal rectangle drawn through the top.



A



B



C

Figure 9.69 Problem 3.

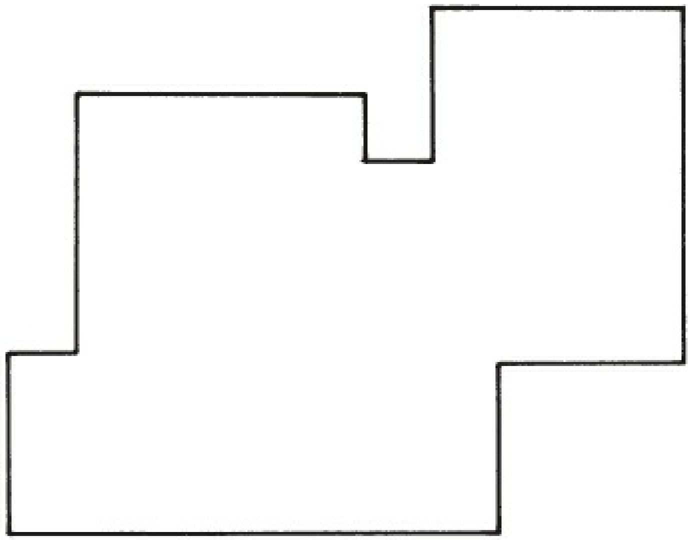
Step II Draw the hip and ridge lines as shown in Figure 9.69B. Identify inside and outside corners, and proceed with drawing both the hip and valley lines.

Step III As the lines overlap each other, which happens in three locations, these locations are identified with dotted lines (see Figure 9.69C). Notice that three of the four hip lines of the major zone are eliminated in the process.

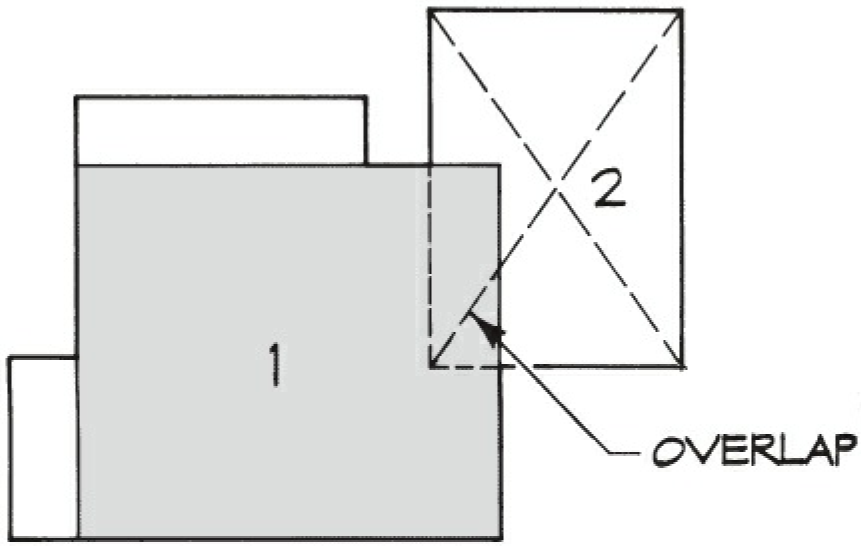
There are configurations in which the major zones are well hidden. There are also shapes that have overlapping zones. These are by far the most difficult challenges. The following five…step example demonstrates a solution for such cases.

Solution to Problem 4

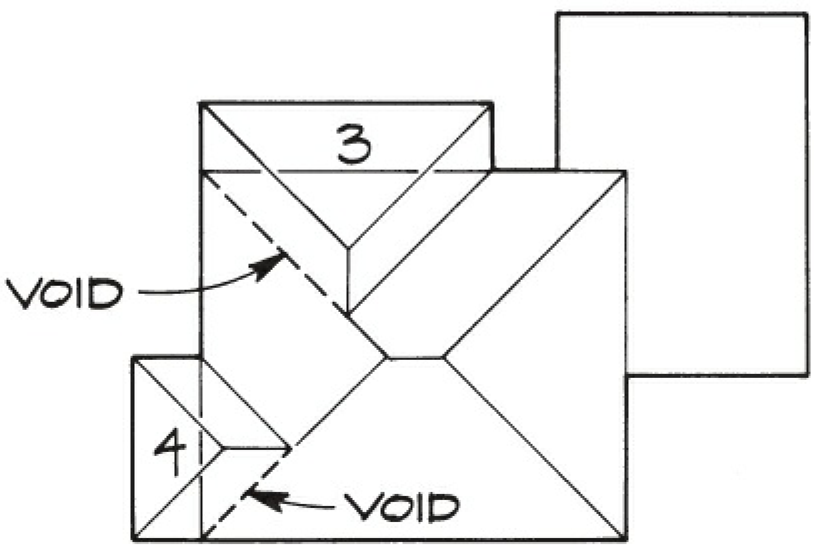
Step I Covering all but the top illustration, see if you can identify the major zone on this outline of the structure in Figure 9.70A.



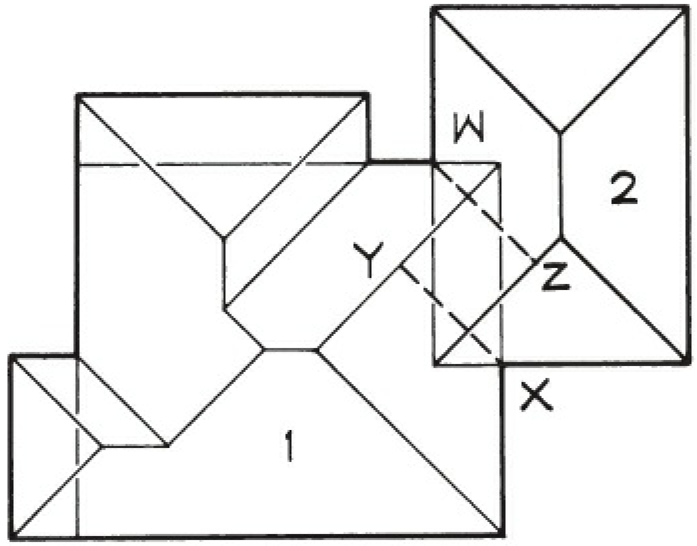
A



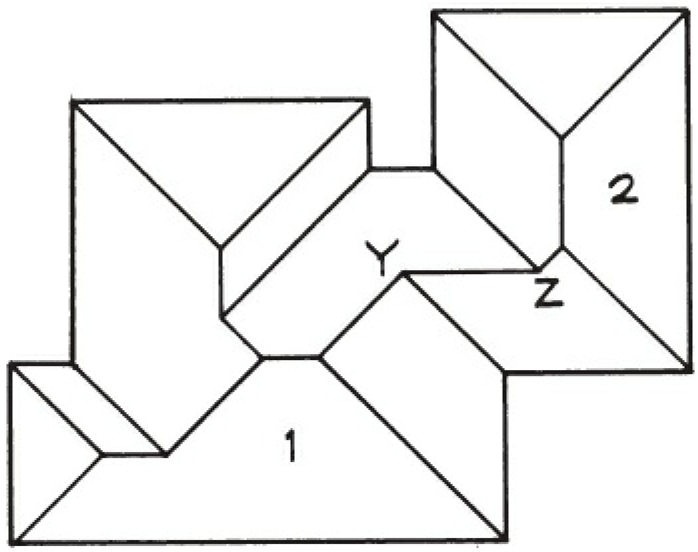
B



C



D



E

Figure 9.70 Problem 4.

Step II Validate your initial selection with Figure 9.70B. Next, identify the second largest zone, which has been “X”ed out. Notice the overlap of zones 1 and 2.

Step III Solve zones 3 and 4 next. Two lines will overlap, causing their removal, as shown in Figure 9.70C.

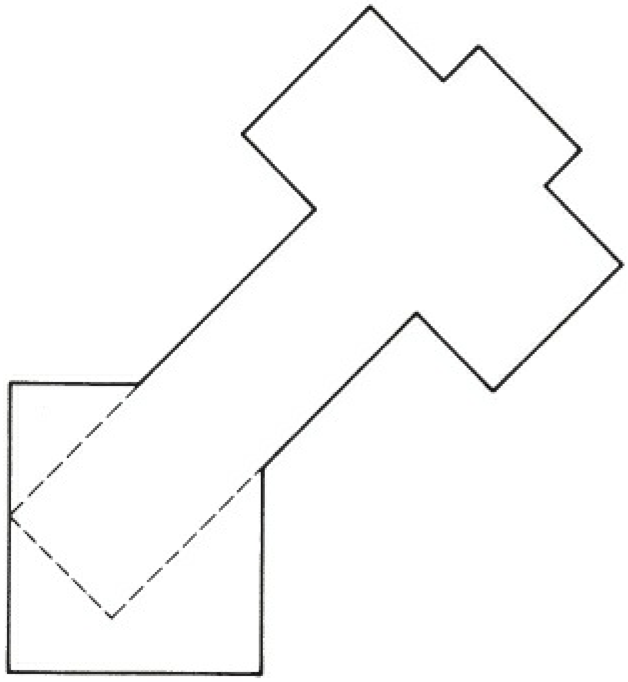
Step IV Zone 2 has inside corners only, as shown in Figure 9.70D. Solve zone 2 as you did zone 1. The points that overlap have been identified with the letters “W” and “X.” These are outside corners, which become valleys. Extend point X toward zone 1, and W toward zone 2. These lines will intersect a hip line, identified by the letters “Y” and “Z,” respectively.

Step V Y and Z are connected to form a ridge (see Figure 9.70E). This ridge is slightly lower than the ridge of zones 1 and 2. The hip lines below points Y and Z are also eliminated to form the final roof configuration.

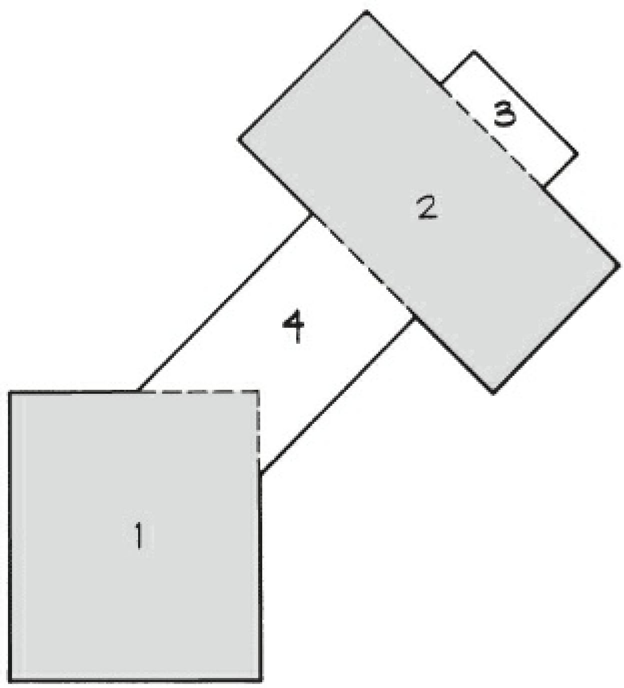
Saving the most challenging for last, we encounter a shape that includes an angle other than 90° around the perimeter. At first glance the task of roofing this outline seems difficult, but if you apply the principles set out in this chapter, the solution is easier than it may first appear.

Solution to Problem 5

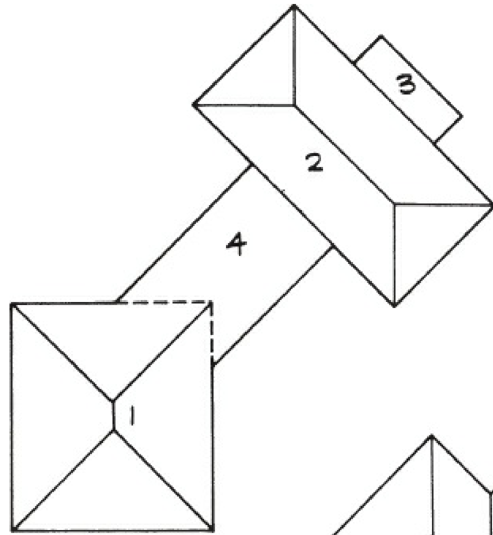
Step I Extending the center portion toward the left (Figure 9.71A) does not produce the rectangle with the largest width, so change your approach and solve the major zoning as explained in the next step.



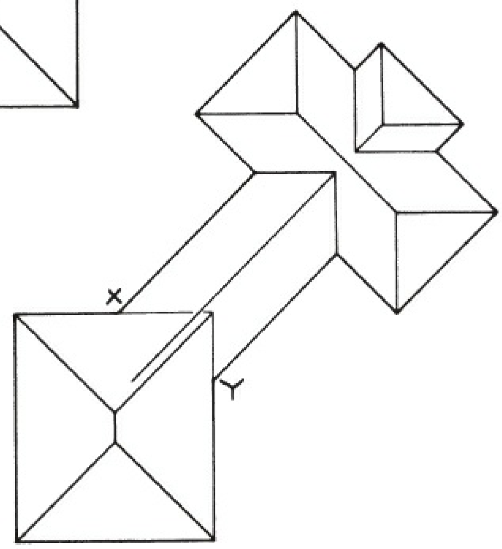
A



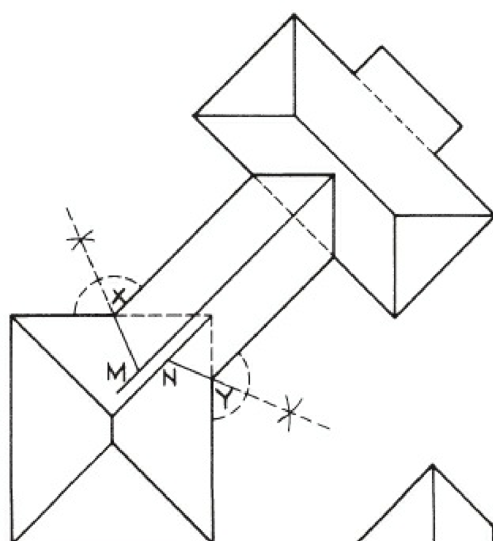
B



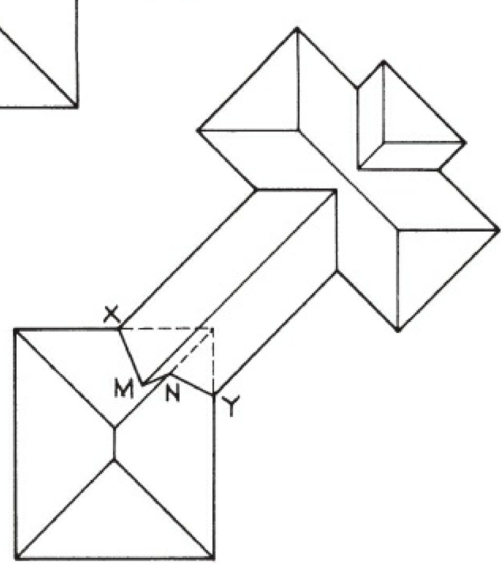
C



D



E



F

Figure 9.71 Problem 5.

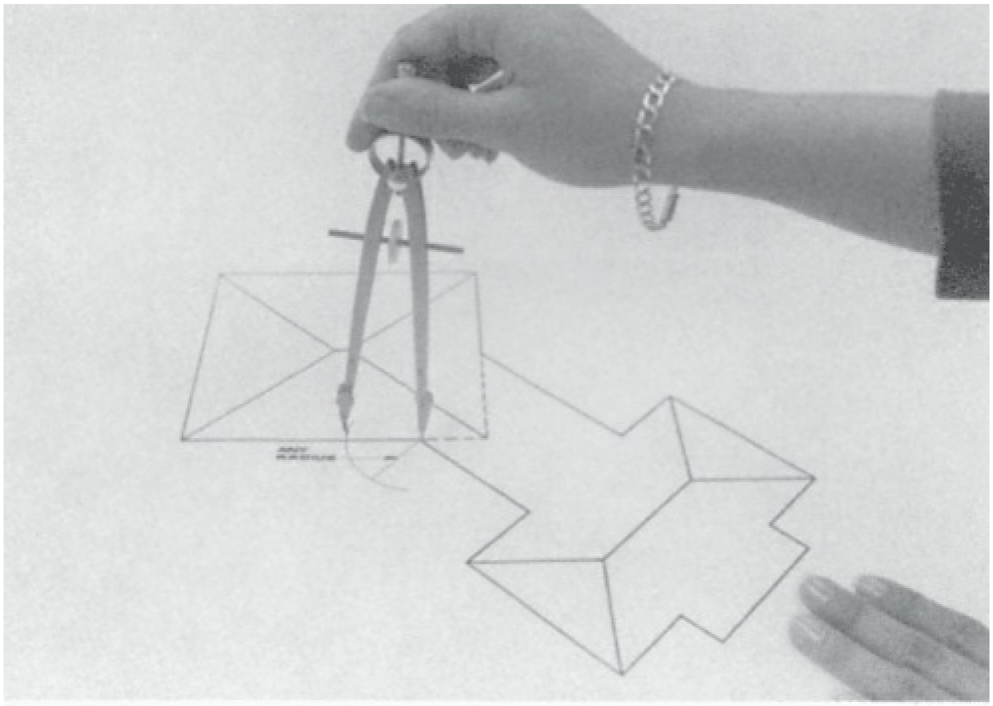
Step II After you have checked the various possible zones, we hope you have selected zones 1 and 2 as shown in Figure 9.71B.

Step III With all inside corners in zones 1 and 2, the solution is simple (see Figure 9.71C). Zone 3 should also be easy, with two inside and two outside corners, and thus will be shown as a finished section in the next step.

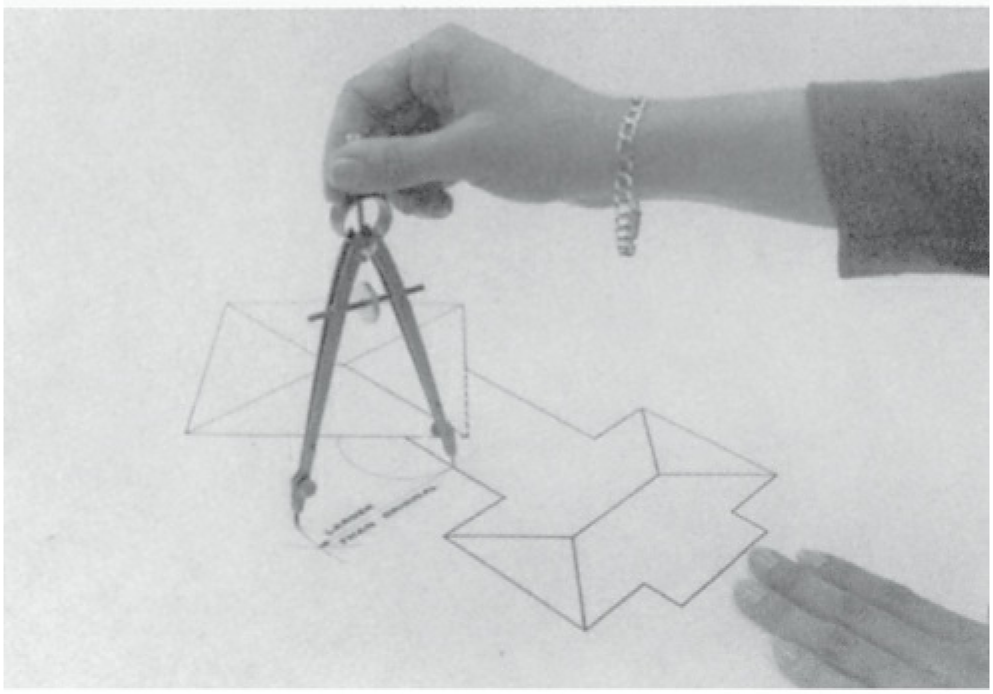
Step IV Zone 4 has four outside corners, two of which overlap zone 1. To find the ridge, use the upper two outside corners and extend the ridge well into zone 1, as shown in Figure 9.71D. The valleys will start at points X and Y.

Because points X and Y are not the normal outside angles (180° or 270°), they must be bisected. It is easier to bisect the outside rather than the inside angle around points X and Y because these angles are less than 180°. This can be accomplished by measuring the angle with a protractor and mathematically dividing the angle, or by using a method, which you may have learned in a basic drafting class or in a geometry class, that requires use of a compass.

The compass is set at any radius and an arc is struck, using X and Y as the center of the arc. See Figure 9.72A. Next, open the compass wider than the original settings and strike two more arcs, starting where the original arc struck the angular lines. See Figure 9.72B. Let's call this new intersection Z. When a line is drawn through Z and X (or Z and Y, depending on which angle you are bisecting), you have bisected the angle.



A



B

[Figure 9.72](#) Bisecting an angle.

Step V Extend the bisecting lines from X and Y to the inside until they hit the ridge. We have identified these points as M and N in [Figure 9.71](#)E.

Step VI Next, connect M and N, as shown in [Figure 9.71](#) F. This line represents another valley at a different angle and defines the true geometric shape of zones 1 and 4 as they intersect each other. The dotted line, which is the underside of the hip of zone 1, is eliminated in a roof plan but may be shown on a subsequent roof framing plan.

Changing Configuration

After having configured an outline of a roof to its correct geometric shape, you can readily convert it to other than a hip roof. For example, consider the roof shown in Figure 9.73A.

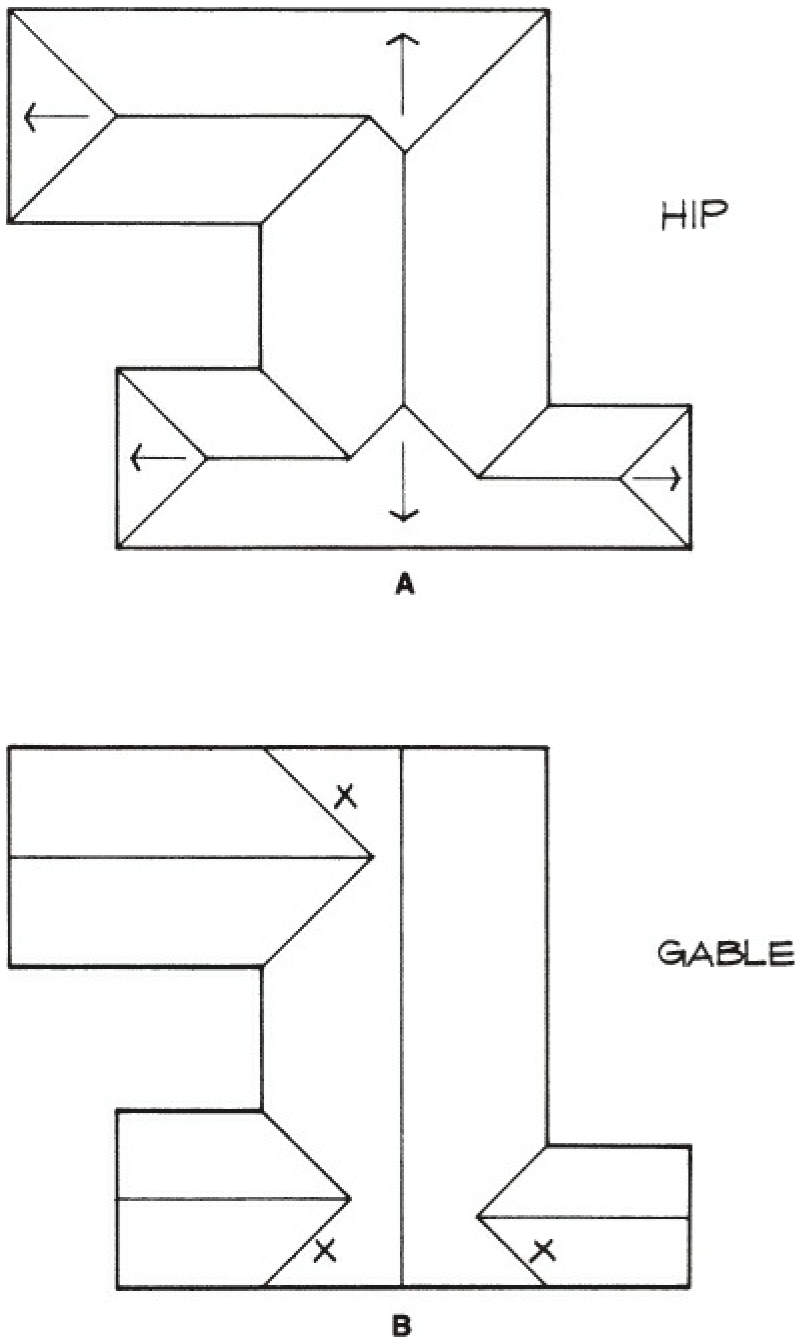


Figure 9.73 Changing configuration.

To change this roof to a gable roof, you simply extend the ridges to the edge of the roof, as shown by the arrows. The final gable roof is displayed in Figure 9.64B. Notice the return of the valley lines (marked X).

In the next example, found in Figure 9.74, the arrows provide the slight bit of interpretation needed for the top right corner of the structure.

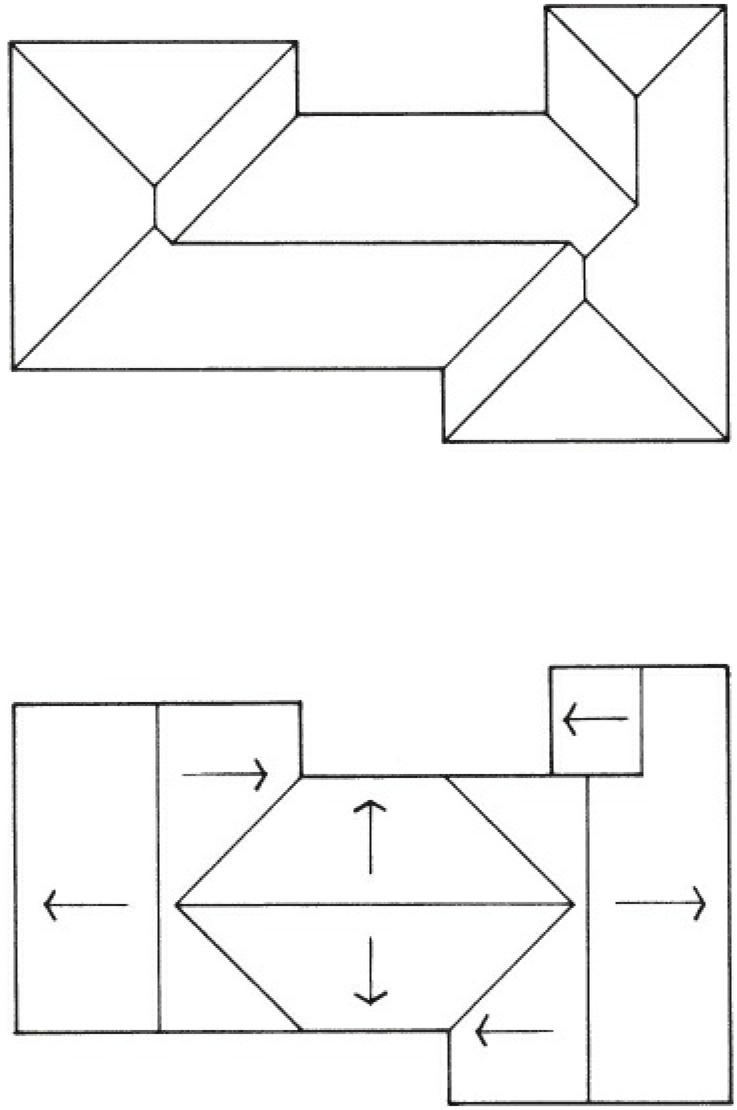


Figure 9.74 Hip to gable conversion.

Skylight Attic Location—Ventilation

A roof plan in conjunction with an exterior elevation gives the designer a perfect opportunity to position and check the appearance of such things as an attic ventilating system that must comply with energy standards. Standards have been instituted by local, state, and even federal commissions for energy conservation. An effective system may be as simple as a screened opening or a screened opening enhanced with a mechanical device.

Because heat rises, it is best to place ventilating systems as high as possible, at the ends of a roof, for thorough ventilation—also taking into consideration the prevailing winds and any other environmental factors that may dictate their position. Code may also allow a reduction of required venting for a combination of high and low vents that encourages **convection**, which is the drafting of the cool air in place of the hot air and vice versa.

Traditionally, ventilation systems were placed on the ends of gable roofs, on the gable portion of a roof, or at the eaves of a hip roof. Today, roof…surface…mounted units and ridge ventilating systems are presently available, as well as numerous mechanical systems for industrial, commercial, and residential structures.

The position of skylights must always be verified on the roof plan. This will ensure that you are not cutting through a strategic area, such as a hip or valley of the roof. For example, the skylight shown at the bottom of Figure 9.75 does not bridge any structural roof member, so it can be placed in the desired location directly above the room below. However, this is not the case with the skylight at the top of this figure, because it crosses a hip member (a pleated plane); therefore, it must be moved to another area, which is shown as a dotted line. The opening below may be in the original position, but with the skylight shifted, the light shaft will be bent. See Figure 9.76.

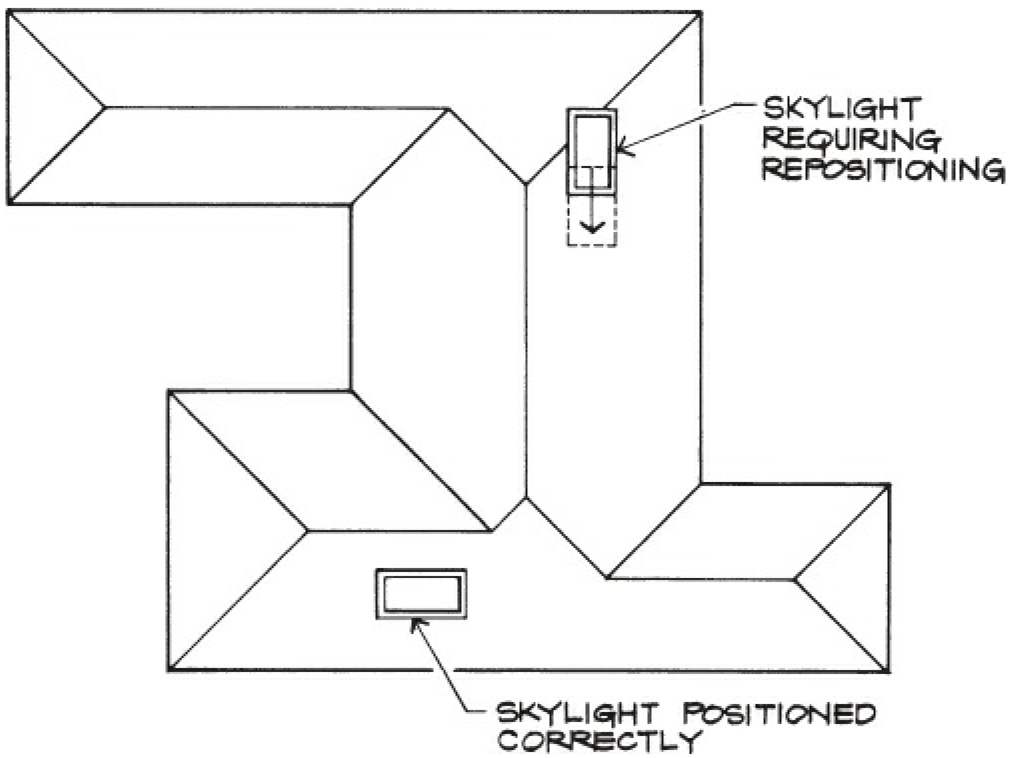


Figure 9.75 Verifying skylight location.

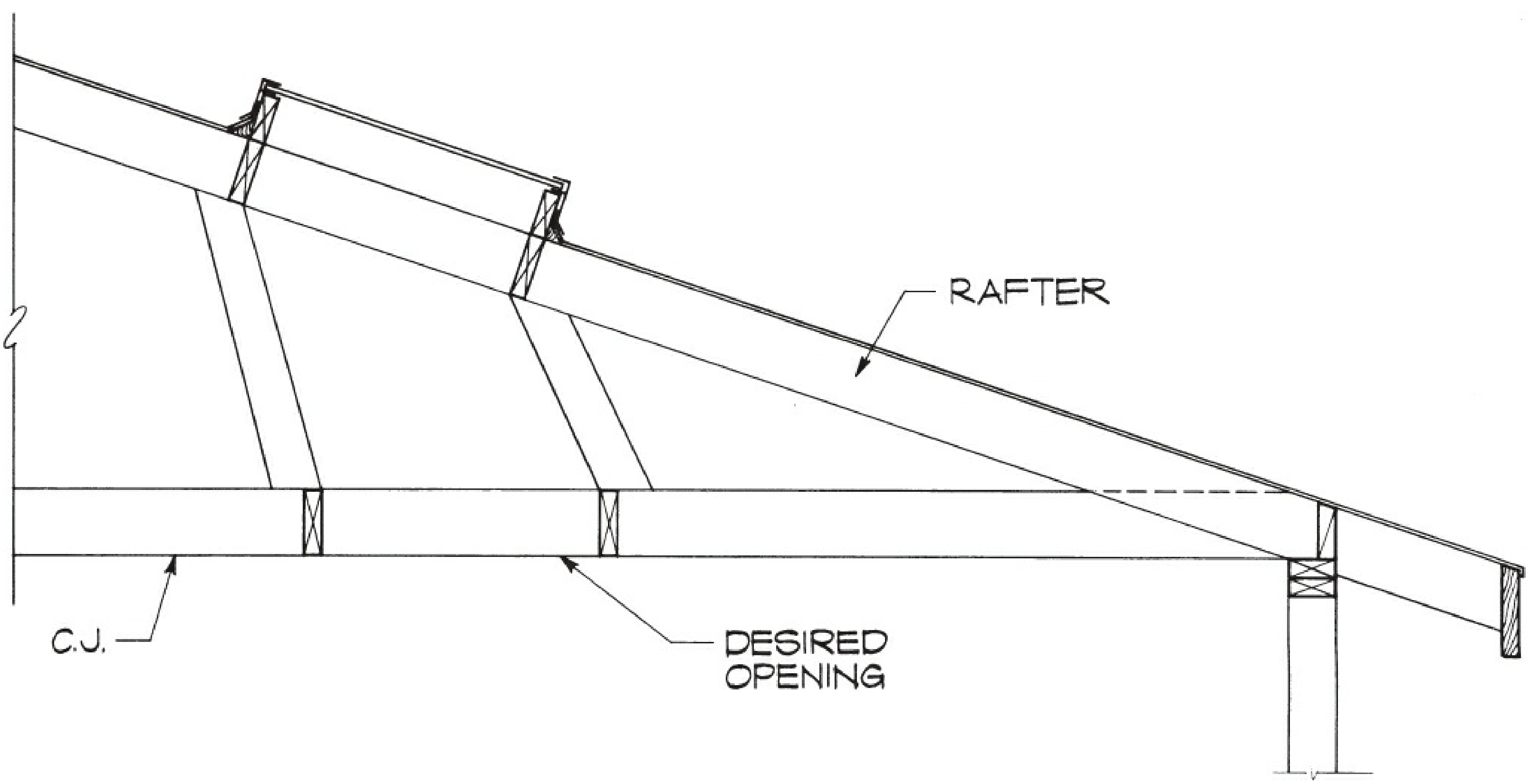


Figure 9.76 Skylight with bent light shaft.

A Newly Built Major Roof Zone

Rather than restricting yourself to a particular outline, you can alter the configuration with porches, balconies, colonnades, and so on. Simply following the outline of the structure would produce an unusual roof that is difficult to frame. The simple addition of a roof over the entry can protect the entry, create the basis for a better structural form, and even simplify the roof form. See Figure 9.77. A simpler roof allows easier construction and creates a system that is structurally stable; thus, if it answers a functional need (covered entry), it is the best of all solutions. See Figure 9.78.

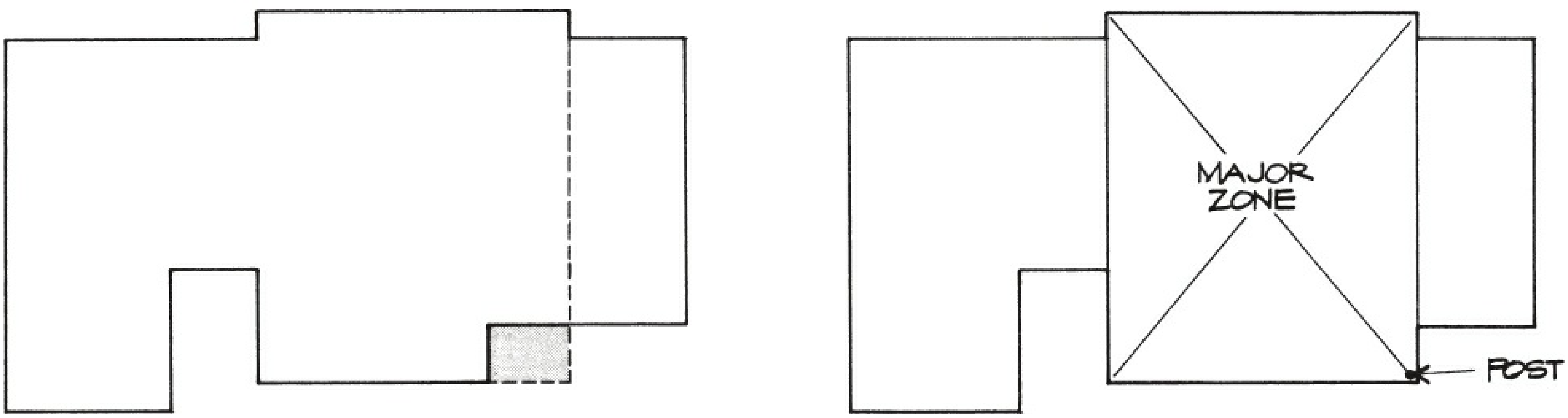


Figure 9.77 Changing the outline.

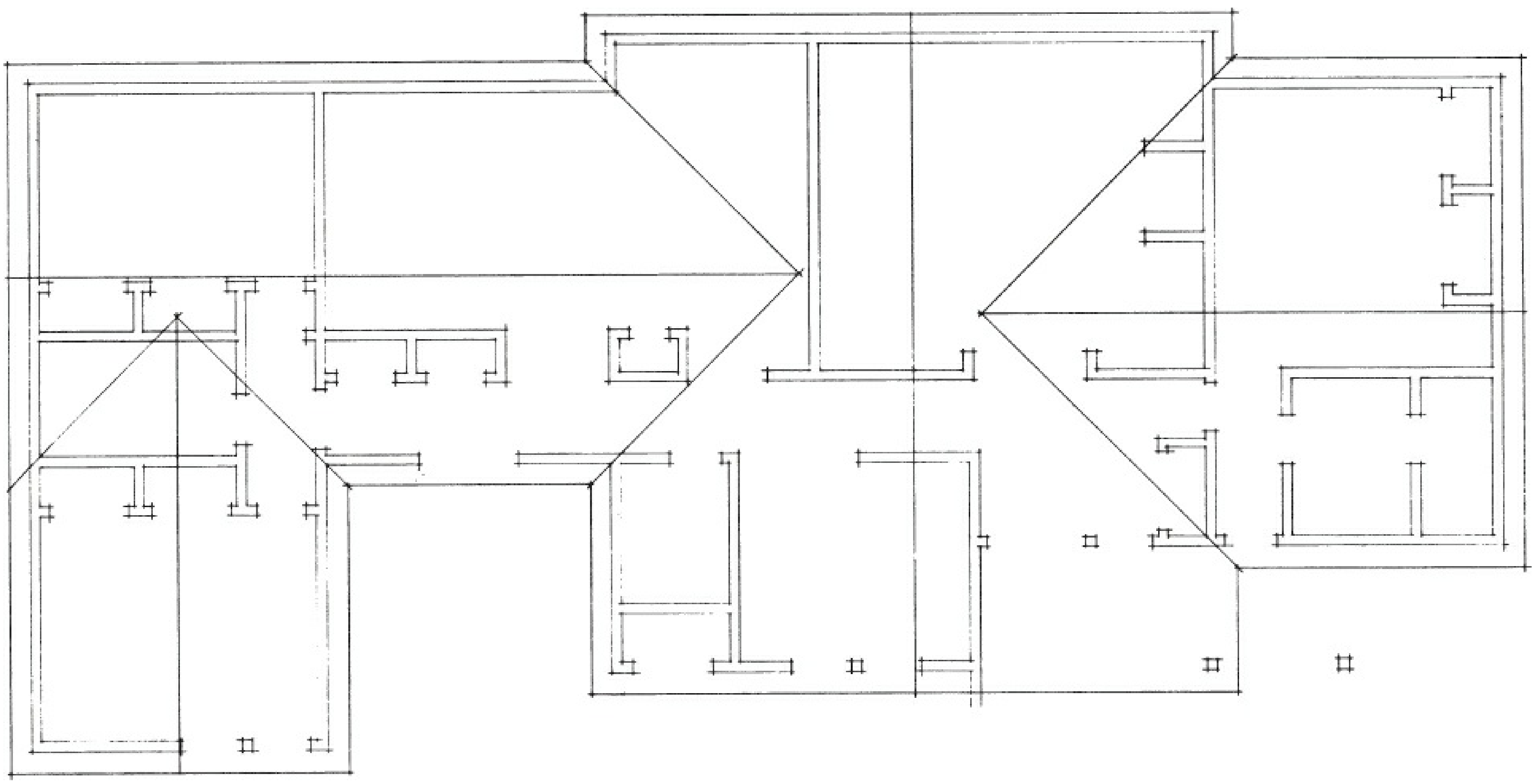


Figure 9.78 Roof to match zoning.

Drawing a Roof Plan on the Computer

Stage I The roof plan shown in Figure 9.79 requires an accurate drawing of the perimeter of the structure. One of the initial stages of the floor plan becomes the datum and should be XREFed into the system.

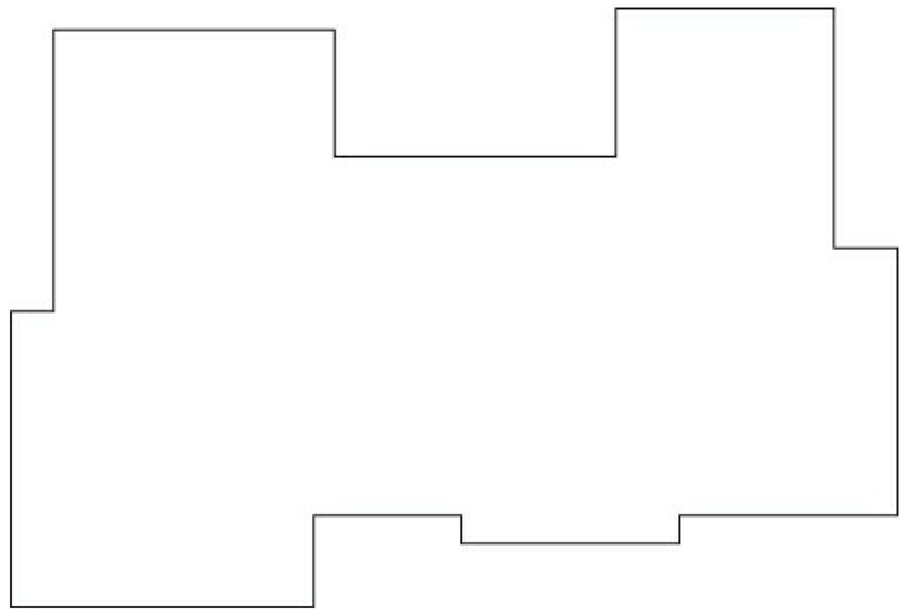


Figure 9.79 Stage I: Datum.

Stage II (Figure 9.80). Add to the outline the various zones to be roofed by isolating the geometry used by the designer and later used by the structural engineer to properly structure this geometric form with its component parts.

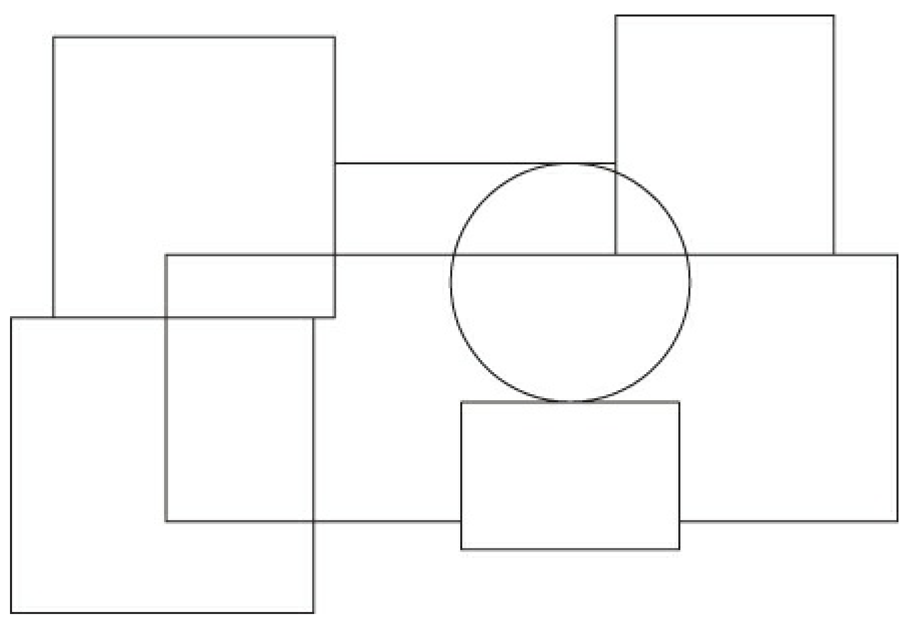
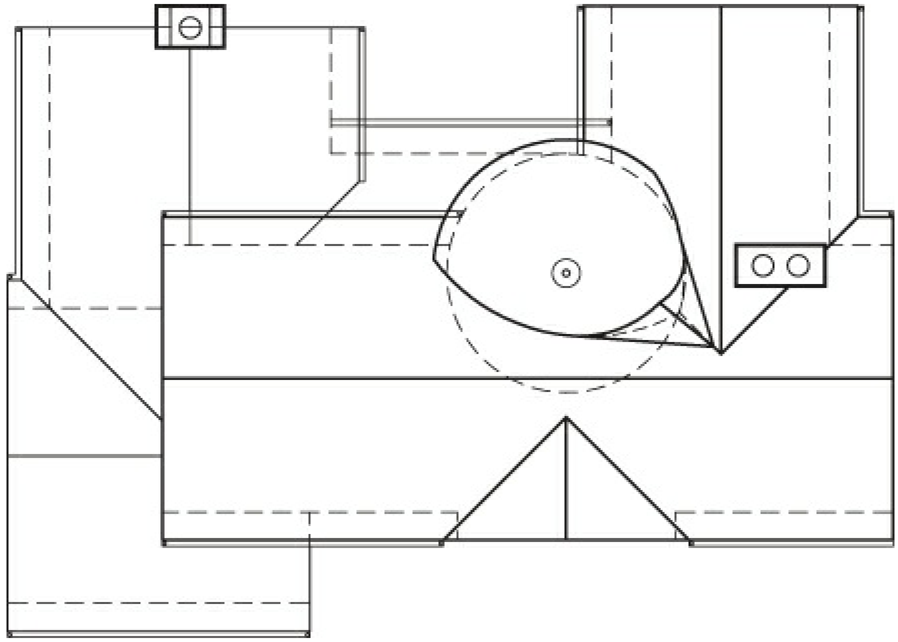


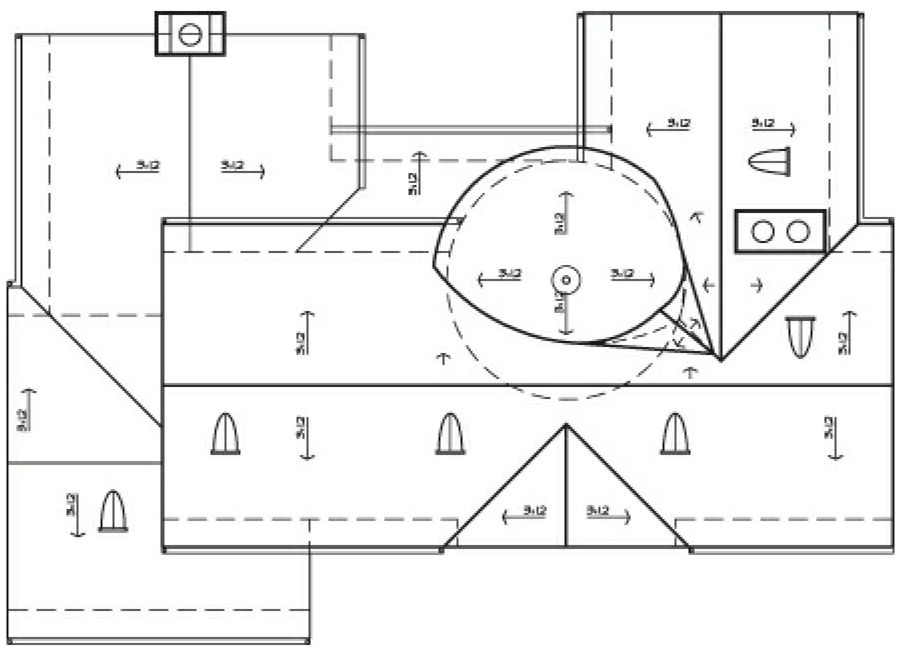
Figure 9.80 Stage II: Isolating geometry.

Stage III (Figure 9.81). The chimney to the fireplace and skylights are positioned, and the roof ridges and valleys are added to the roof structure.



[**Figure 9.81**](#) Stage III: Defining roof shape.

Stage IV ([Figure 9.82](#)). Skylights and chimneys that cut through ridges and valleys are resolved through detailing. Roof slopes and venting of the attic are done at this stage. Heat rises, so it is recommended that the ridge vents be placed as high atop the roof as possible. A portion of the roof may be hatched or delineated to show the roof material covering this structure.



[**Figure 9.82**](#) Stage IV: Chimney, slope direction, and vents.

Stage V ([Figure 9.83](#)). The plotting and titling stage may include elevation **call-outs** of the top of the roof. This is typically required when the municipality has height restrictions.

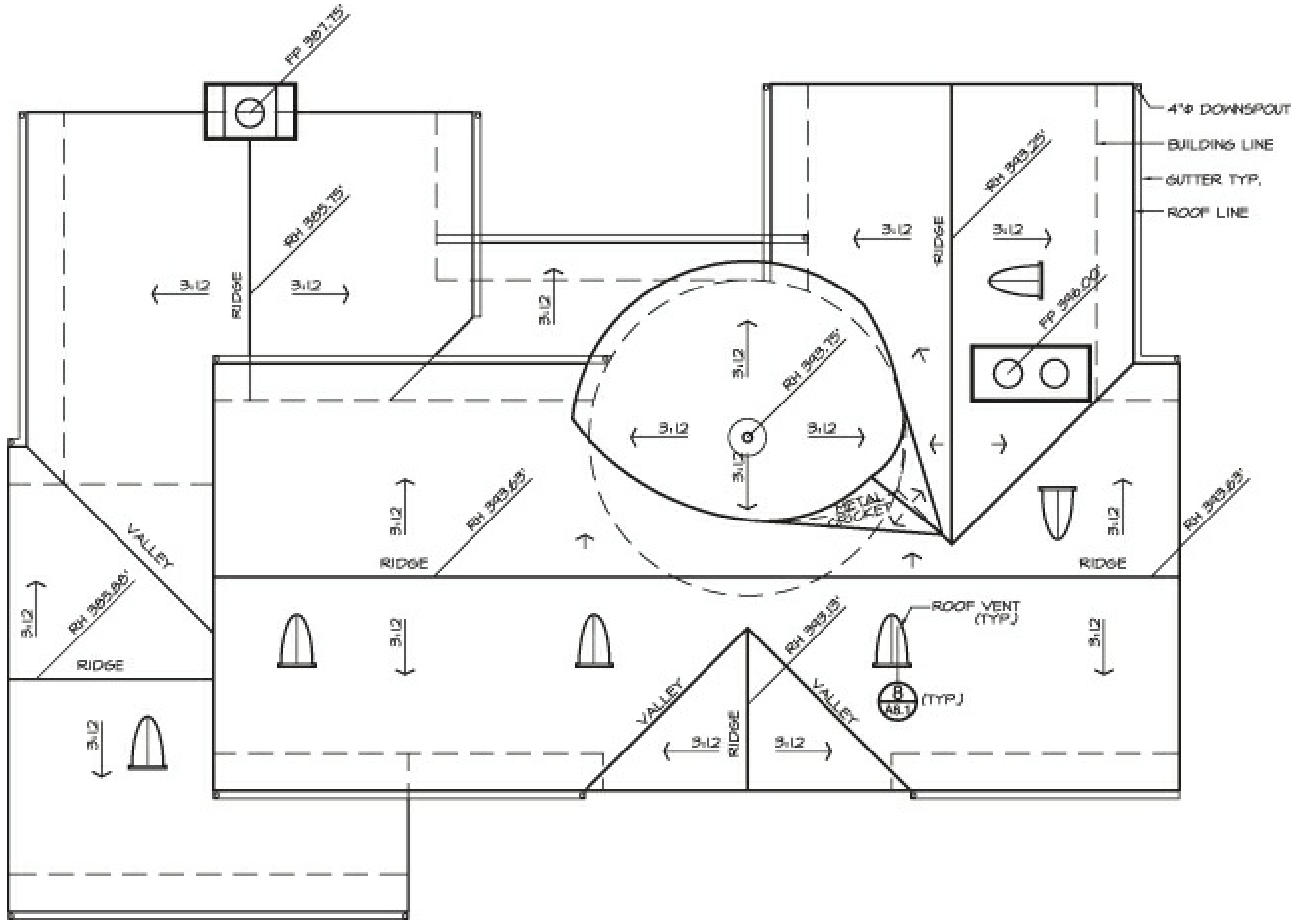


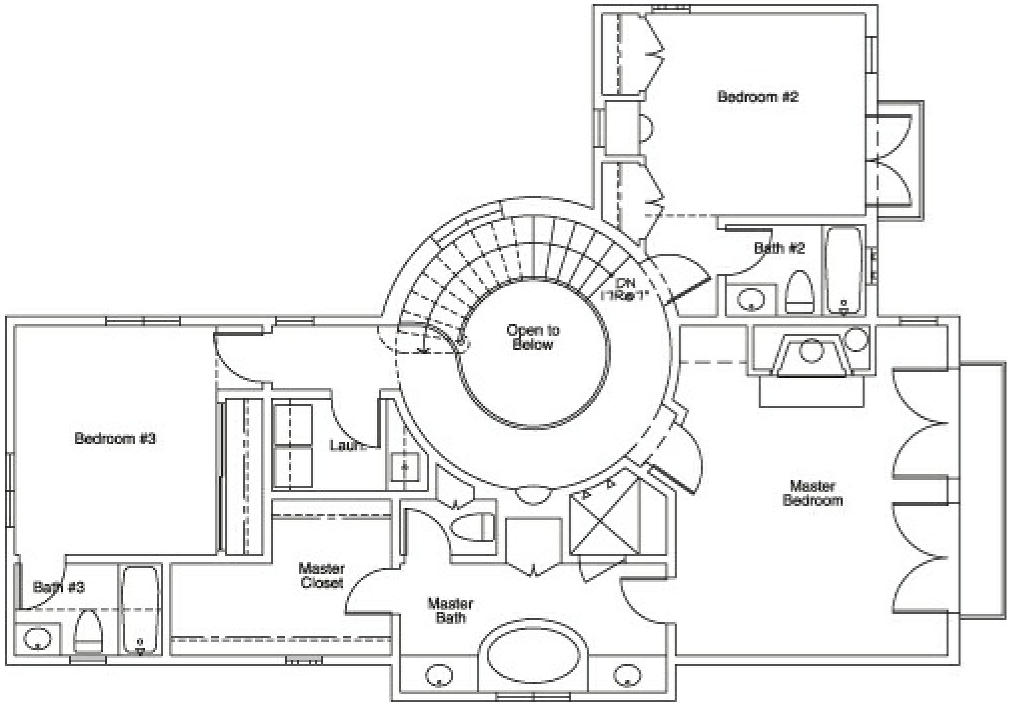
Figure 9.83 Stage V: Noting.

Drawing a Roof Framing Plan on the Computer

The roof framing plan may be drafted by a structural engineer; an alternate, and usually less expensive, strategy may be to provide the structural engineer with a set of digital drawings on which the engineer may calculate the sizes for all of the necessary structural components (rafters, headers, sheet walls, etc.). These can then be translated in the architectural office as a CAD drawing.

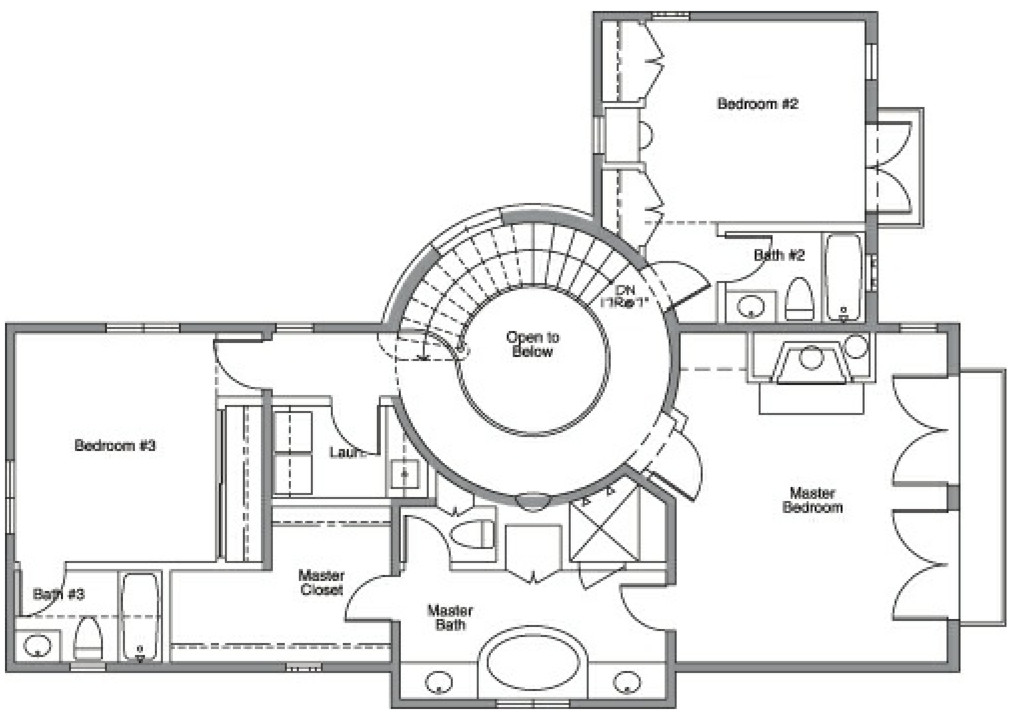
For a better understanding of the system that will be used to build the roof structure, refer to the examples in Chapters 3 and 4.

Stage I (Figure 9.84). An early stage of the second…floor plan becomes the datum for the evolution of this drawing.



[Figure 9.84](#) Stage I: Floor plan as datum.

Stage II ([Figure 9.85](#)). The walls that are bearing the weight of the roof are identified.



[Figure 9.85](#) Stage II: Identifying bearing and non…bearing walls.

Stage III ([Figure 9.86](#)). With the bearing and non…bearing walls identified, the drafter will not have any trouble in also placing the direction and duration symbols on the drawing. The drafter can also isolate the most important headers and beams listed by the engineer and isolate critical beams that may be missing from the engineer's sketch. Shear walls are also located, drawn, and referenced to a schedule.

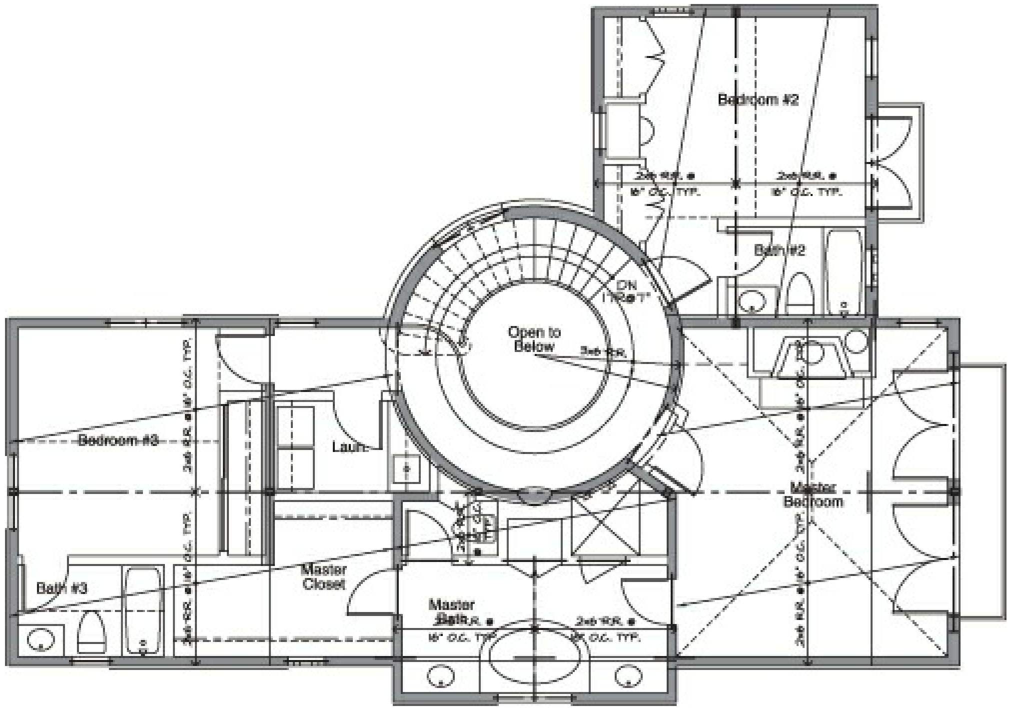
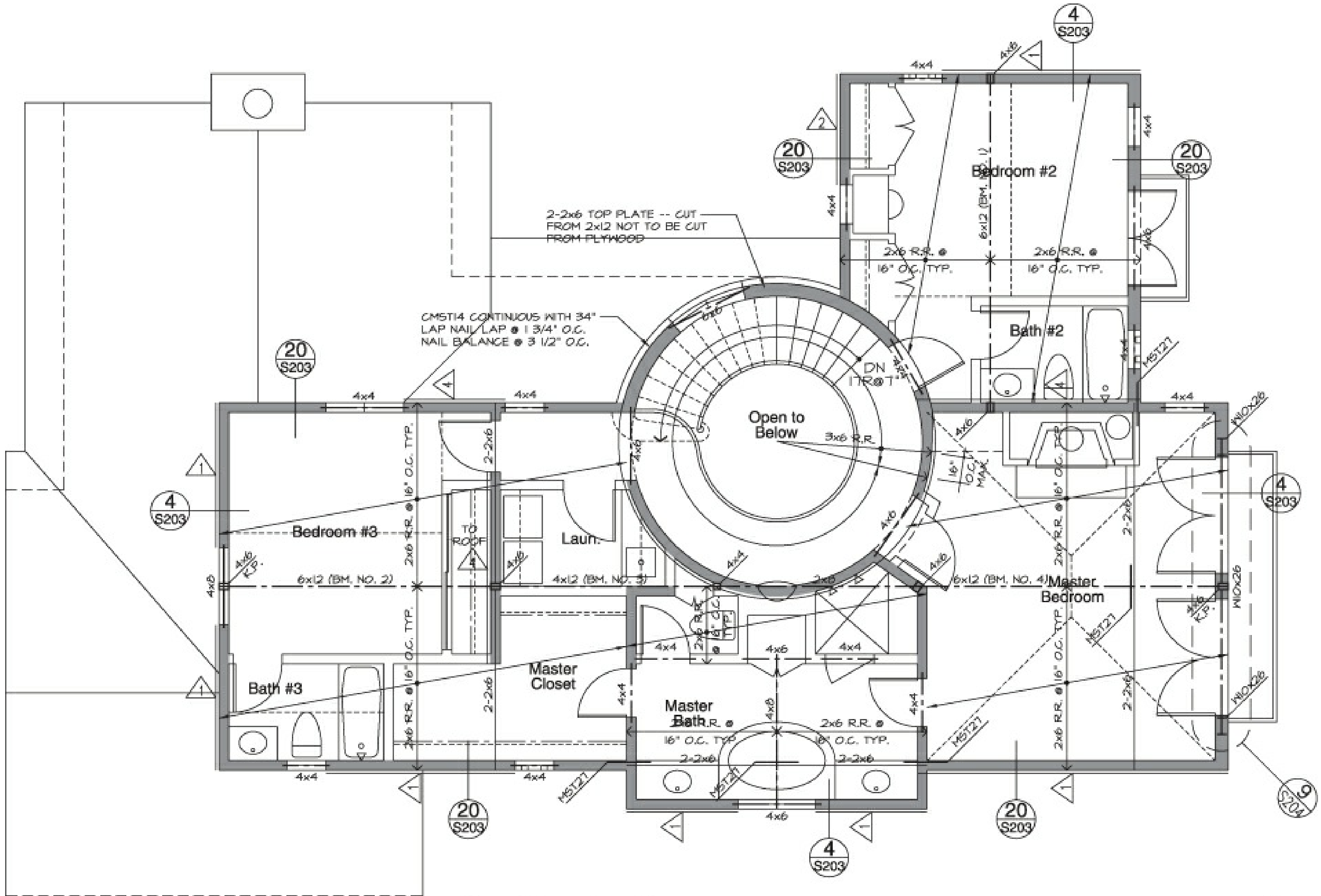


Figure 9.86 Stage III: Direction, duration, shear, and beams.

Stage IV (Figure 9.87). All noting and referencing occurs in this stage.



Roof Framing Plan

SCALE: 1/4" = 1'-0"

Shearwall Schedule

SYMBOL	PANEL	NAILING [3] COMMON NAILS	WALL LBS/FT	SOLE PLATE ATTACHMENT NAILS	SOLE PLATE ATTACHMENT LAGS [9]	SOLE PLATE ATTACHMENT ANCHOR BOLTS [6]	TOP PLATE [4] ATTACHMENT	HOLDOWN [5,6]
1	3/8 EXPOSURE I [7] (ID#24/0)	8d @ 6,6,12	198	16d @ 6" O.C.	3/8" x 5" @ 24" O.C.	5/8" DIA. @ 48" O.C. 12" LONG	A35 @ 24" O.C.	HD2A, CB44, FTA2 PHD2
2 [1]	15/32 EXPOSURE I [7] (ID#32/16)	10d @ 4,4,12	244	16d @ 3.5" O.C.	3/8" x 5" @ 18" O.C.	5/8" DIA. @ 48" O.C. 12" LONG	A35 @ 16" O.C.	HD5A, CB44, FTA2 PHD5
3 [1,2,3] 3x SILL	15/32 EXPOSURE I [7] (ID#32/16)	10d @ 3,3,12	450	40d @ 3" O.C.	3/8" x 5" @ 12" O.C.	5/8" DIA. @ 32" O.C. 14" LONG	A35 @ 12" O.C.	HD6A, CB44, FTA5 PHD6
4 [1,2,3] 3x SILL	15/32 EXPOSURE I [7] STRUCT. I (ID#32/16)	10d @ 2,2,12	652	50d @ 3" O.C.	3/8" x 5" @ 8" O.C.	5/8" DIA. @ 24" O.C. 14" LONG	A35 @ 8" O.C.	HD8A, FTA7, PHD8

FOOTNOTES:

1. THESE PANELS TO BE 4-PLY MINIMUM.
2. 3x SOLE PLATES AND 3x FRAMING AT ADJOINING PANEL EDGES REQUIRED. STAGGER PANEL EDGE NAILING.
3. 1/2" MINIMUM EDGE DISTANCE REQUIRED FOR BOUNDARY NAILING.
4. A35'S NOT REQUIRED IF PANEL NAILS TO FRAMING MEMBER ABOVE TOP PLATES.
5. HOLDOWNS REQUIRED AT ENDS OF ALL SHEAR PANELS. USE 4x4'S FOR END MEMBERS. ALL HOLDOWN BOLTS TO BE TIGHTENED JUST PRIOR TO COVERING, INSPECTOR TO VERIFY. BOLT HOLES TO BE 1/16" MAXIMUM OVERSIZED AT THE CONNECTION OF THE HOLDOWN TO THE POST, INSPECTOR TO VERIFY.
6. SIMPSON BP WASHERS REQUIRED FOR ALL PLYWOOD SHEAR WALL SILL PLATE BOLTS AND HOLDOWN BOLTS.
7. OSB (ORIENTED STRAND BOARD) IS A WOOD STRUCTURAL PANEL.
8. SOLID BLOCKING SHALL BE PROVIDED AT ALL HORIZONTAL JOINTS OCCURRING IN BRACED WALL PANELS.
9. USE 3x BLOCKS AND 3x RIM JOISTS IF LAGS ARE USED.

Figure 9.87 Stage IV: Noting.

(Courtesy of James Orland, CE.)

Drawing Framing Members on the Floor Plan

This first method illustrates and notes ceiling and/or floor framing members directly onto the finished floor plan. It is a good method to use when the framing conditions are simple and do not require many notes. The goal is to reference symbols that will not be confused

with the other finished floor‐plan information.

Figure 9.88 shows the lower‐floor plan of a two‐story residence. This plan contains all the information and symbols needed. Note how the ceiling joist size, spacing, and direction are illustrated in bedroom #1 and the study. Note also the use of broken lines to represent exposed ceiling beams in the master bedroom. As you can see, if a great deal more framing information were required, the drawing would lose its clarity.

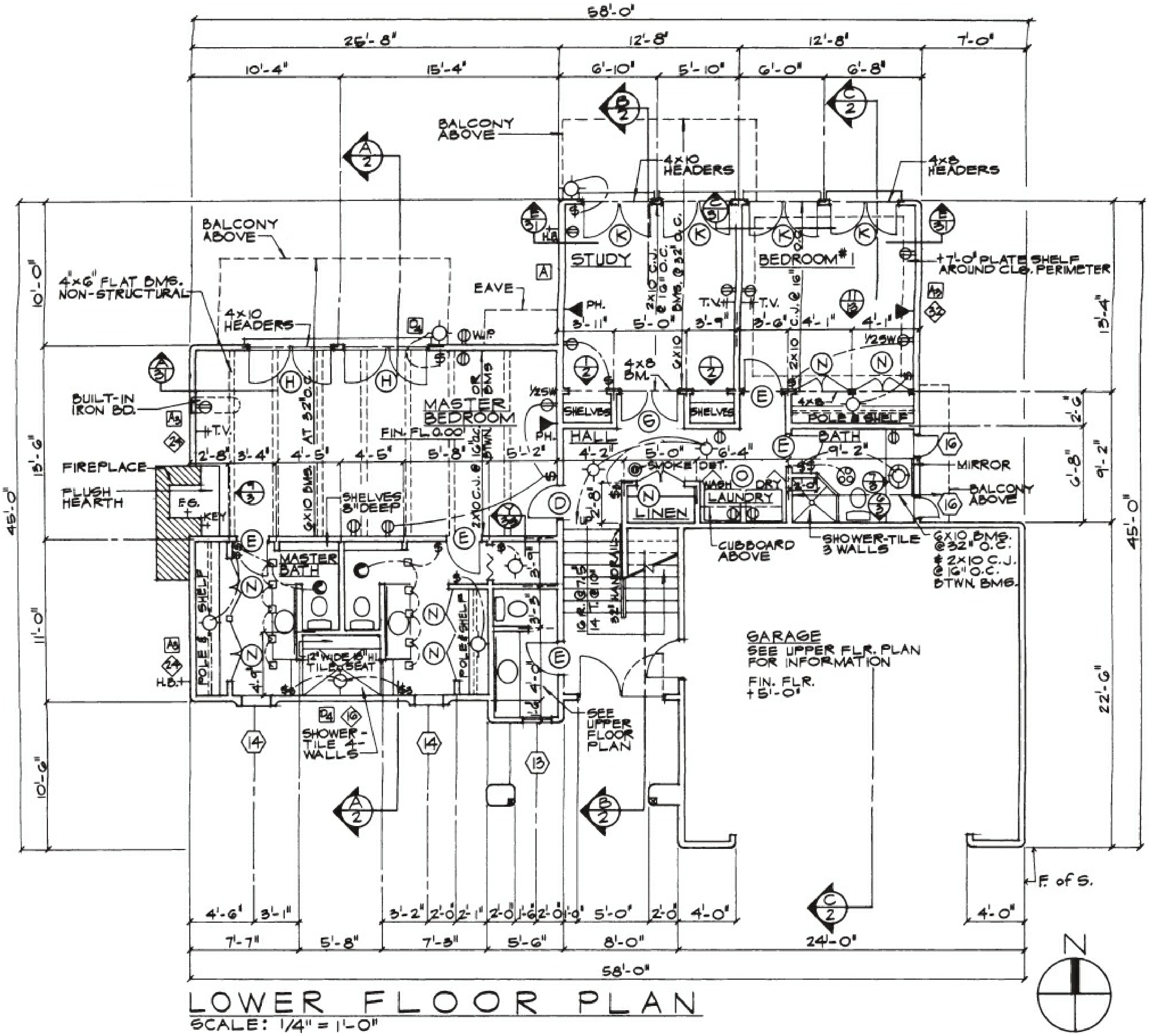
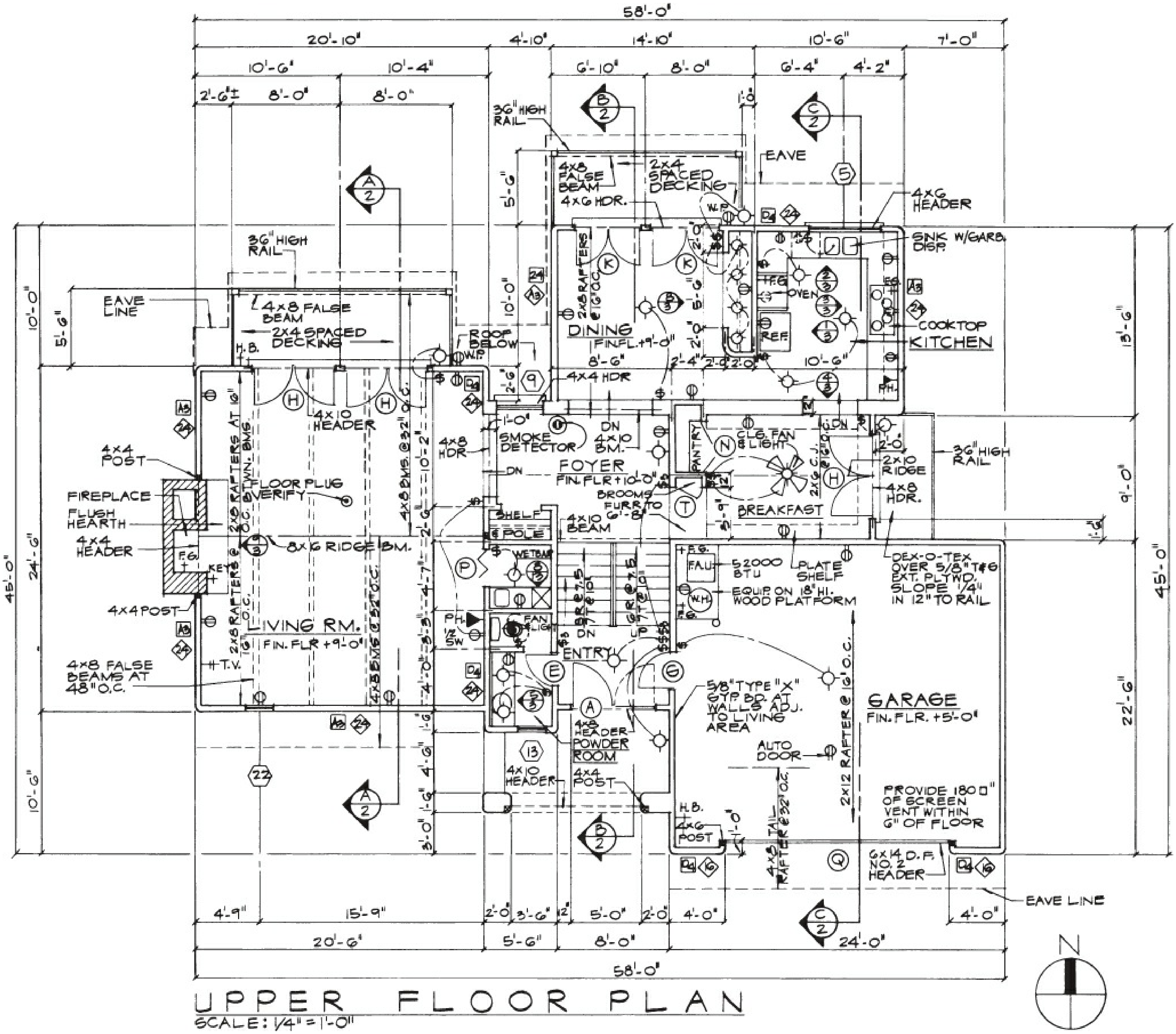


Figure 9.88 Ceiling framing on finished floor plan.

(Courtesy of William F. Smith—Builder.)

The upper‐floor plan of this residence designates ceiling joist sizes, spacing, and direction, as well as roof framing information such as rafter sizes, spacing, and direction; ridge beam size; and the size and spacing of exposed rafter beams in the living room. See

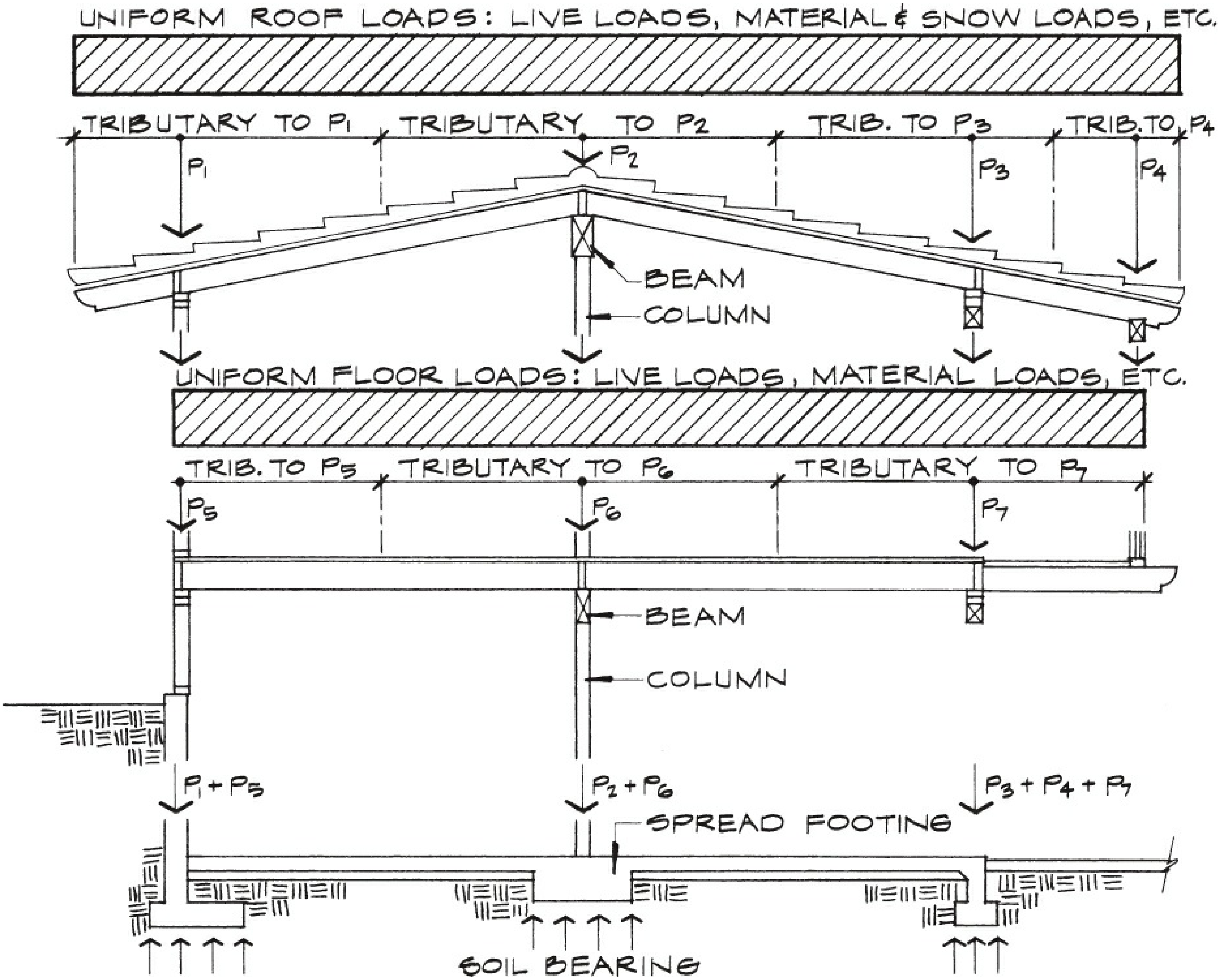
[Figure 9.89](#). Headers and beams for framing support over openings are also shown in this figure. If you are using this method to show framing members, you can delineate beams with two broken lines at the approximate scale of the beam or with a heavy broken line.



[Figure 9.89](#) Ceiling and roof framing on finished floor plan.

(Courtesy of William F. Smith—Builder.)

The structural design of beams and footings is calculated by finding the total loads that are distributed to any specific member. This total load is found by computing the tributary area affecting that member. [Figure 9.90](#) illustrates a cross‥section showing the various tributary areas that contribute loads to the ridge beam, floor beam, and foundation footing.



[Figure 9.90](#) Tributary loading section.

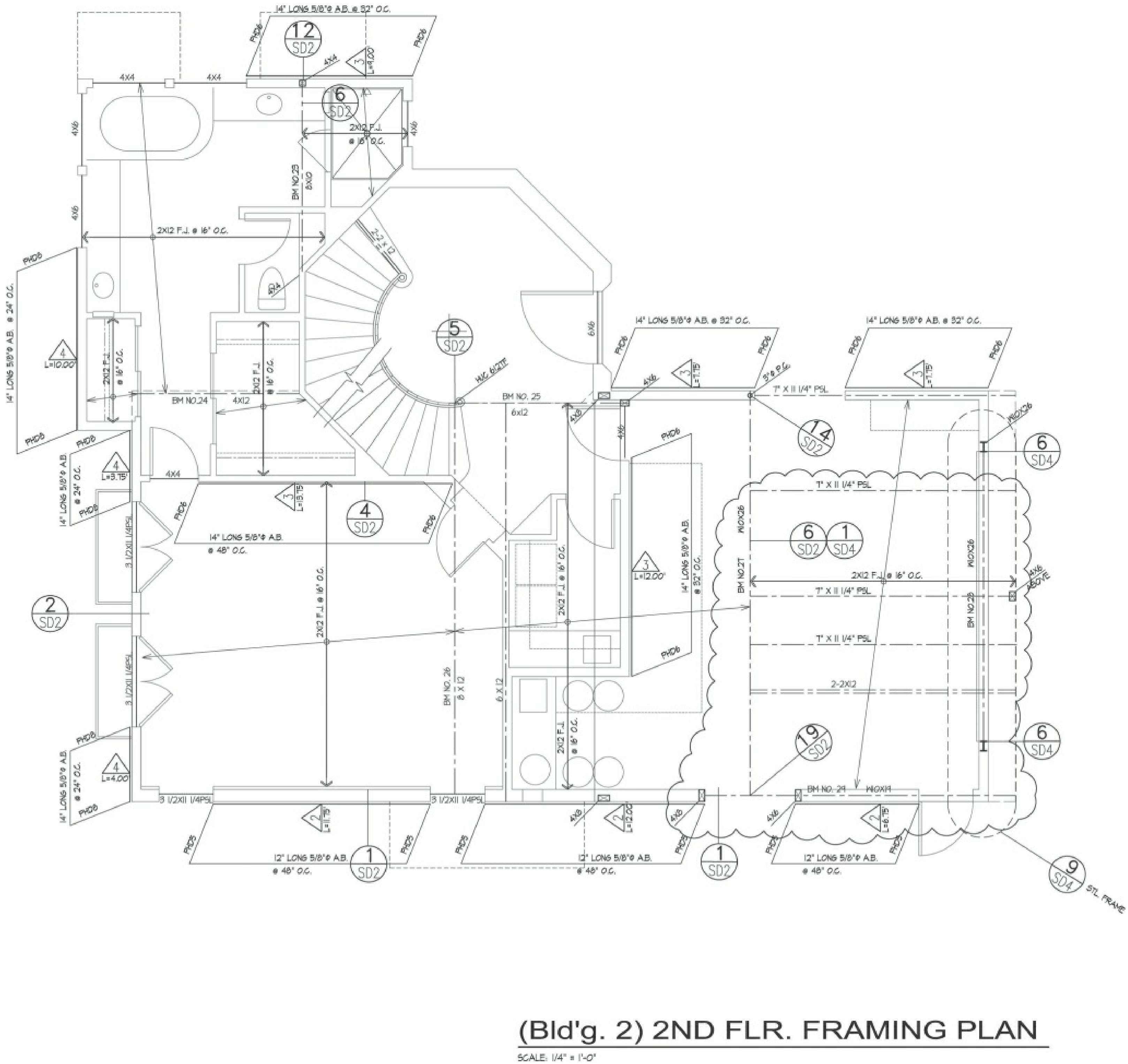
Drawing Framing Members Separately

The second way to show ceiling, floor, and roof framing members is to provide a separate drawing that may be titled “2nd Floor Framing,” “Floor Framing,” or “Roof Framing.” You might choose this method because the framing is complex or because construction document procedures require it.

The first step is the same as that taken when drawing on the foundation plan. Duplicate or XREF all the walls, windows, and door openings. The line quality of your tracing should be just dark enough to make these lines distinguishable after you have reproduced the drawing. In this way, the final drawing, showing all the framing members, can be made darker like a finished drawing. This provides the viewer with clear framing members, while the walls are just lightly drawn for reference.

[Figure 9.91](#) shows the floor plan of the first floor of a two…story, wood…framed residence

with all the framing members required to support the second floor and ceiling directly above this level. Because the second‐floor framing and ceiling for the first floor are the same, this drawing is titled “2ND FLR. Framing Plan.”



[Figure 9.91](#) Second‐floor framing plan.

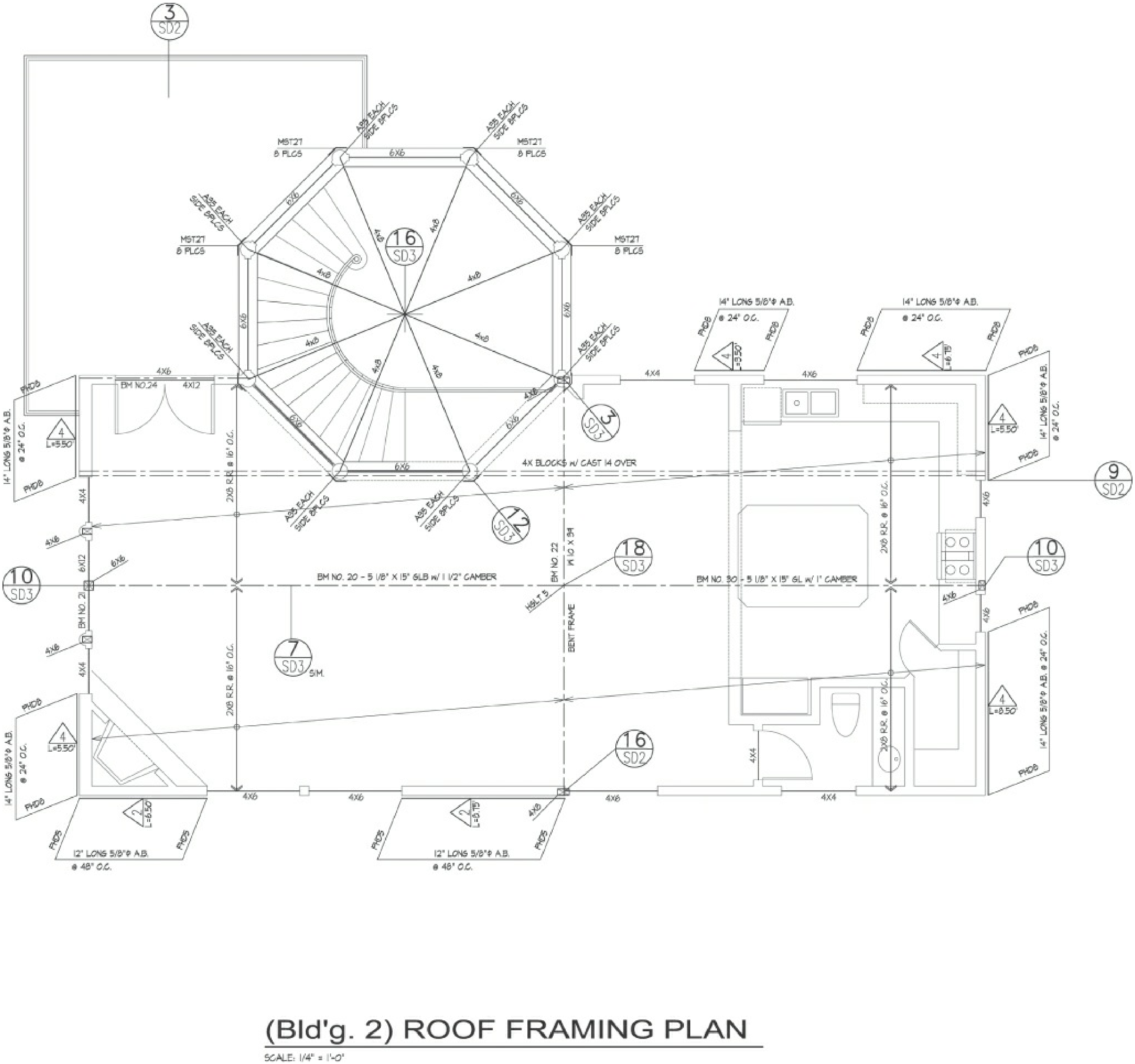
(Courtesy of James Orland, CE.)

First, draft in all the floor beams, columns, and headers for all the various openings. Then incorporate the location and span direction of all the floor joists into the drawing. In [Figure 9.91](#), the floor joist locations and span directions are shown with a single line and arrowhead at each end of the line. This is one way to designate these members. Another method is shown later when the roof framing plan is discussed.

Dimensioning for framing plans mainly applies to beam and column locations. Provide dimensioning for all floor beams and columns located directly under load…bearing members. These members, such as walls and columns, are located on the second floor. Dimensioning for these members is similar to that on a floor plan. When you have finished the drawing, provide the required notes for all the members included in the drawing.

Drawing the ceiling plan for the second…floor level involves only the immediate ceiling framing members. A ceiling plan will typically be incorporated into the roof framing plan unless it is too complex. In that case, it will show headers over openings and ceiling joist location, span, direction, size, and spacing for a specific ceiling area. This is also where applicable notes and dimensioning are shown.

The final framing plan for this project is the roof framing plan. See Figure 9.92. As mentioned previously, another way to show framing members is to draw in all the members that apply to that particular drawing. This obviously takes more time to draw, but is clearer for the viewer.



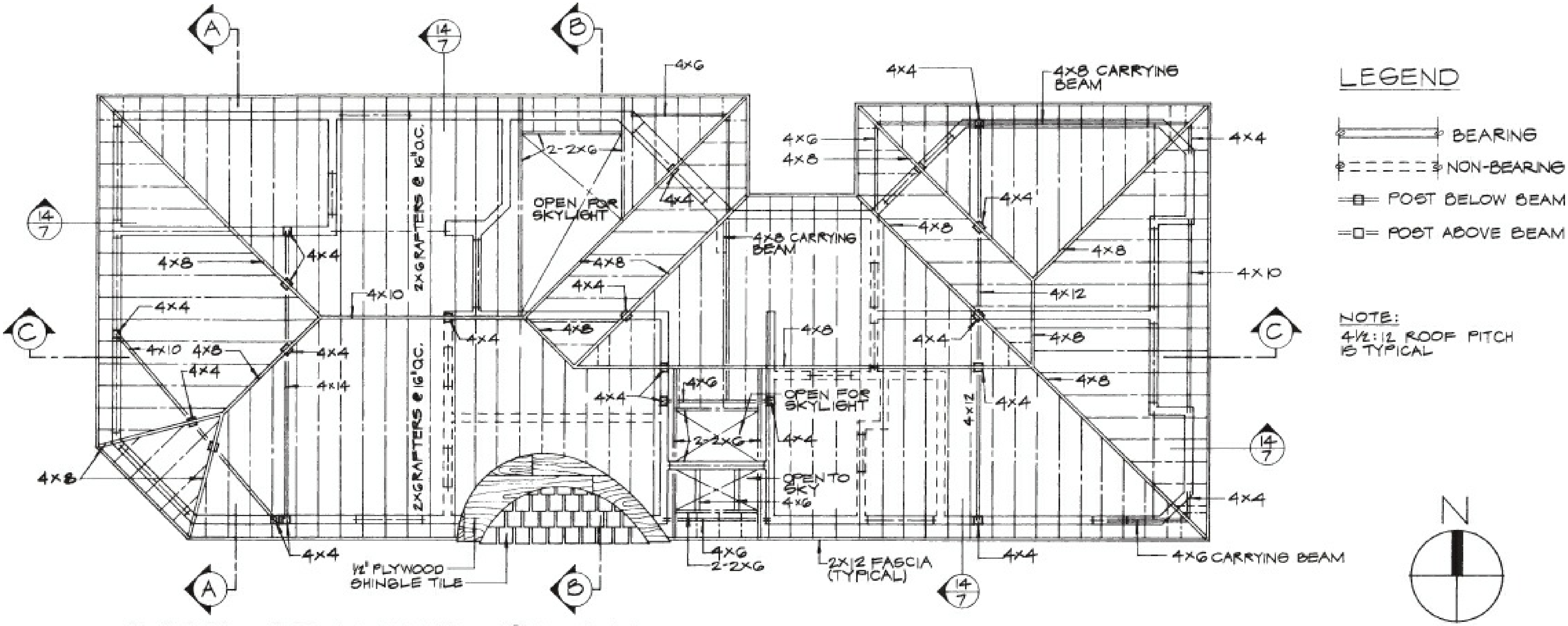
[Figure 9.92](#) Roof framing plan.

(Courtesy of James Orland, CE.)

Framing Plan: Wood Members

When wood structures have members spaced anywhere from 16″ to 48″ on centers, show them with a single line broken at intervals. [Figure 9.93](#) shows the roof framing plan for this residence, which incorporates all the individual rafters, ridges, **hip rafters** (the members that bisect the angle of two intersecting walls), and supporting columns and beams under the rafters. Show the rafters, which are closely spaced, with a single line. Although this method is tedious, it does provide clarity and an actual member count for

the contractor to work from. Lightly draft the walls so that the members directly above are clear. Provide dimensioning for members with critical locations, as well as call‑outs for the sizes, lumber grade, and spacing of all members.



ROOF FRAMING PLAN

1/4" = 1'-0"

Figure 9.93 Roof framing plan with single line for rafters.

FLOOR FRAMING

Conventions

The basic conventions for floor framing are generally the same as those used in roof or ceiling framing plans.

The floor plan should be used, with XREF. In this manner, not only do you keep the size of the file small, but any corrections or changes in the floor plan will be reflected in the framing plan.

This section discusses a second…floor framing plan that will be drawn onto the first…floor plan. Two systems will be shown, the first with conventional framing and the second with engineered lumber. In discussing engineered lumber, we will show how to use the computer framing program developed by Boise Cascade called “BC Framer.”

Conventional Floor Framing Plan

Stage 1 (Figure 9.94). Use an early stage of the floor plan that shows all the walls and openings in the structure. Fireplaces, elevators, and stairs should be included and externally referenced in the drawing set so that the framing around them can be included.

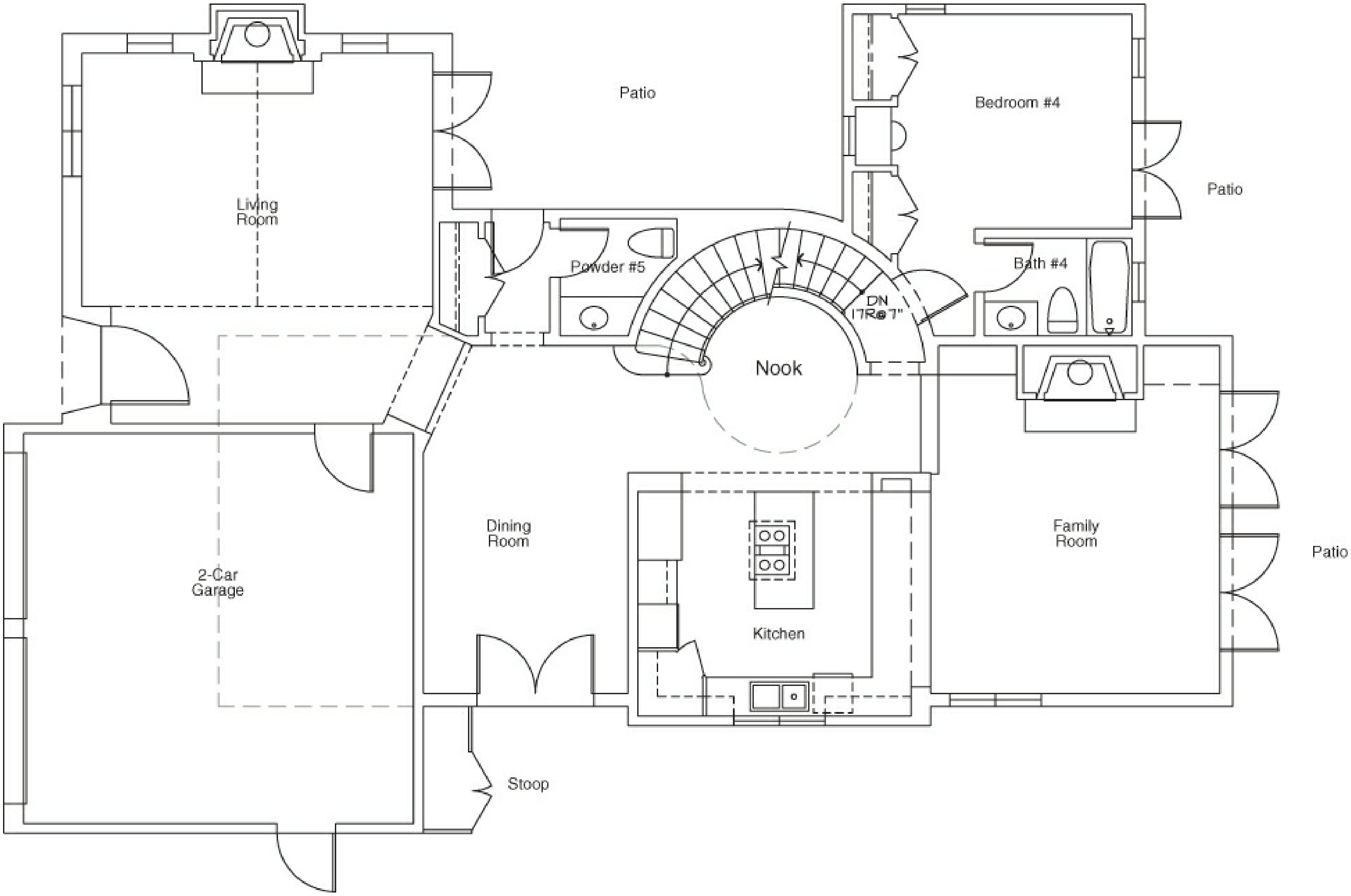


Figure 9.94 Stage I: Datum (first…floor plan).

Stage 2 (Figure 9.95). The various areas to be framed include openings and are identified as zones. An example of the framing that will be employed for openings is shown in Figure 9.96. If not already done, identify any bearing walls with hatching (texturing).

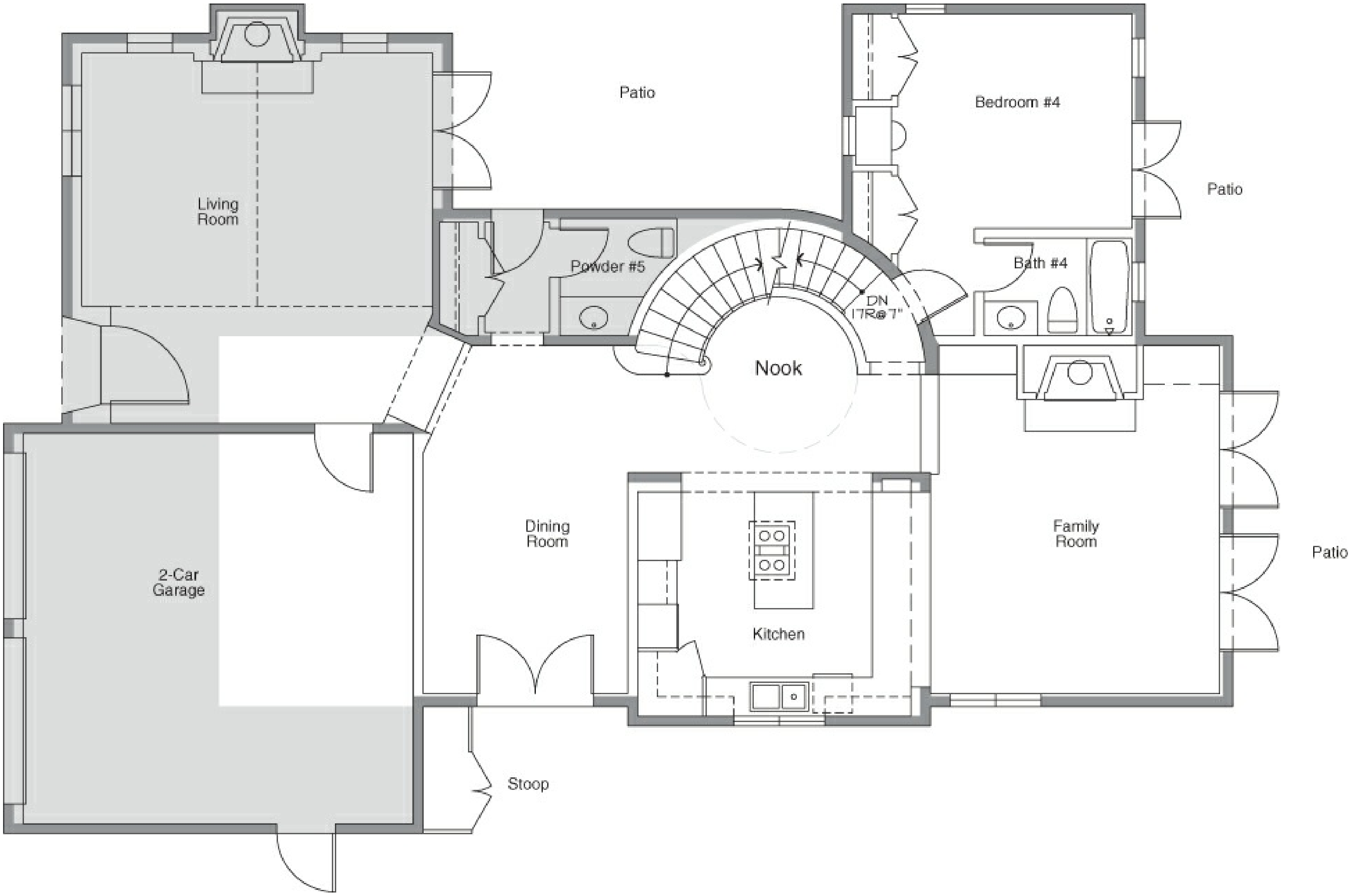


Figure 9.95 Stage II: Selecting zones.

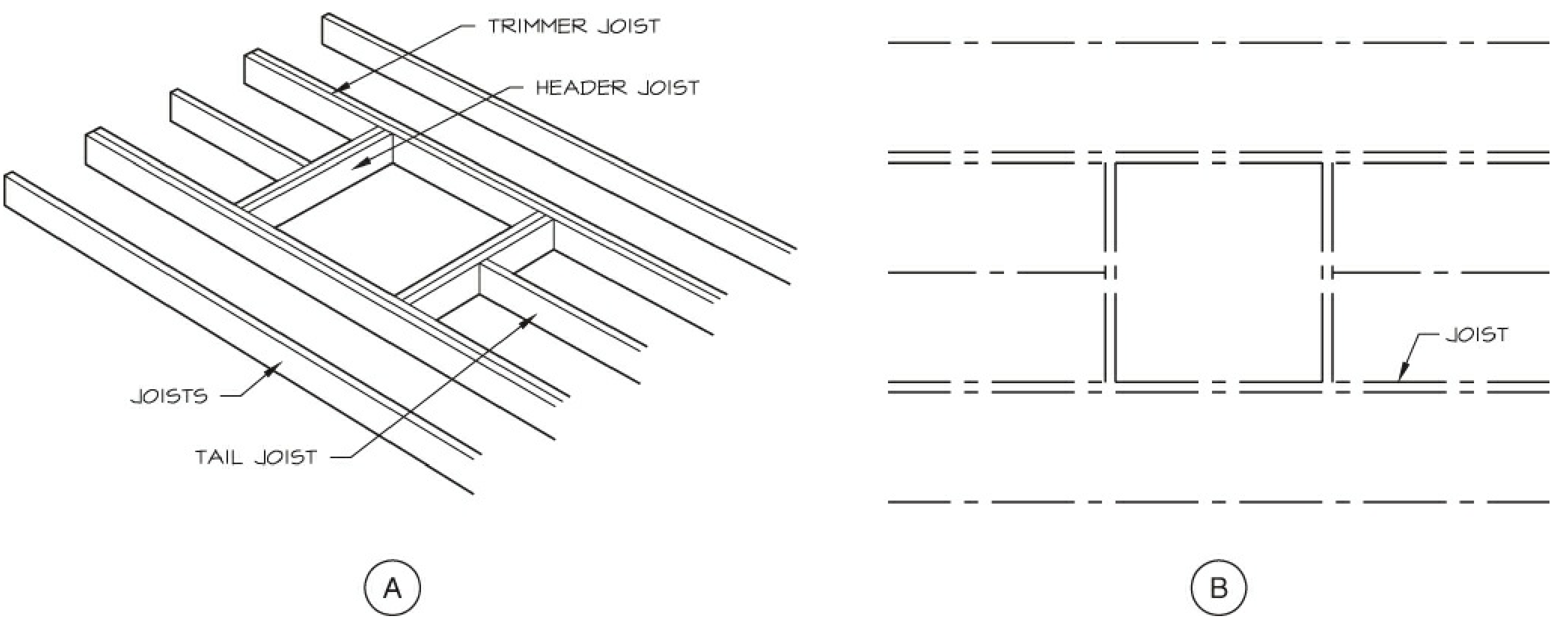
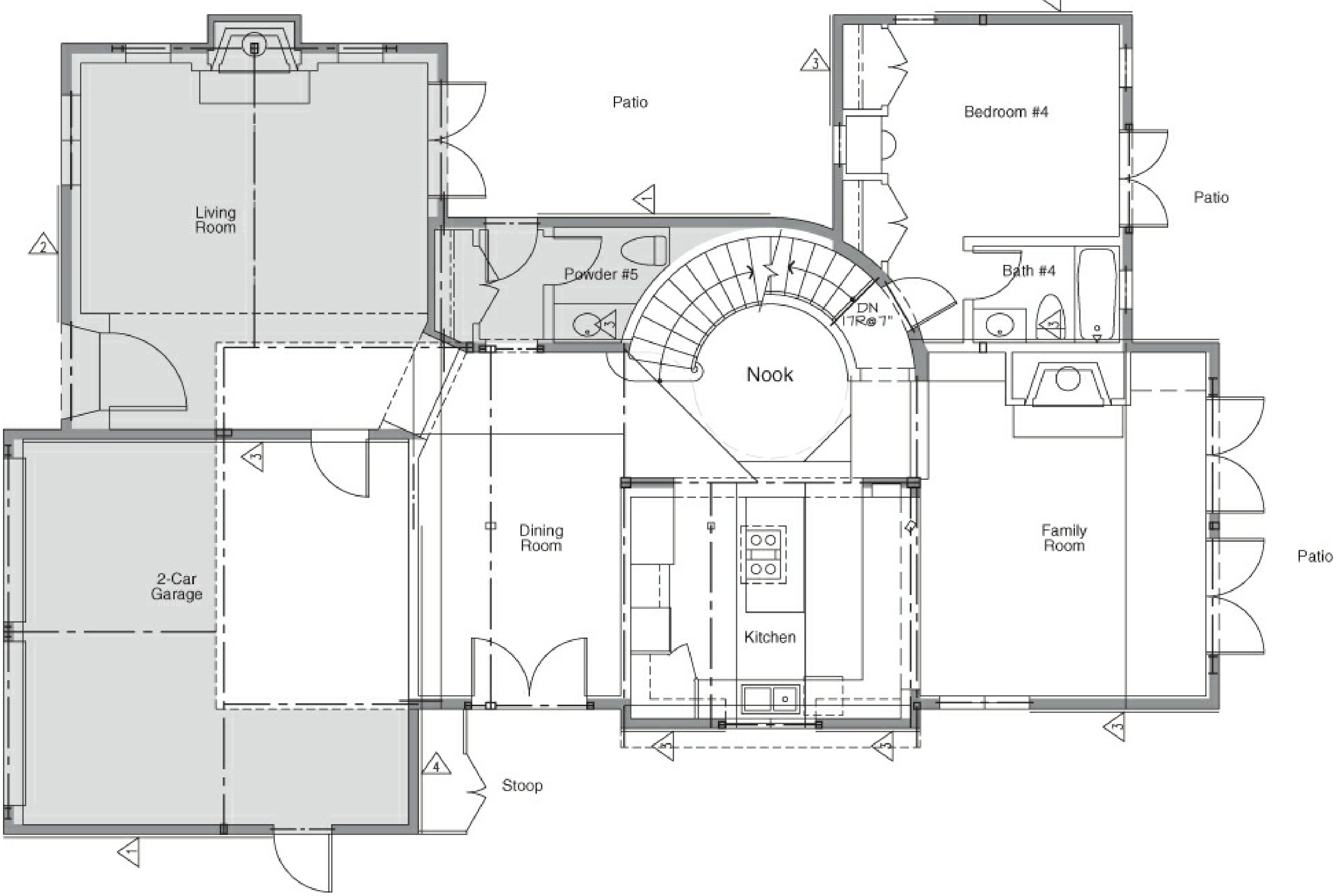


Figure 9.96 Framing an opening.

Stage 3 (Figure 9.97). Shear walls are drawn at this stage and referenced to a schedule that is shown directly below the framing drawing. Headers, beams, and openings are defined, using a centerline. Critical columns and posts should also be identified.



Shearwall Schedule

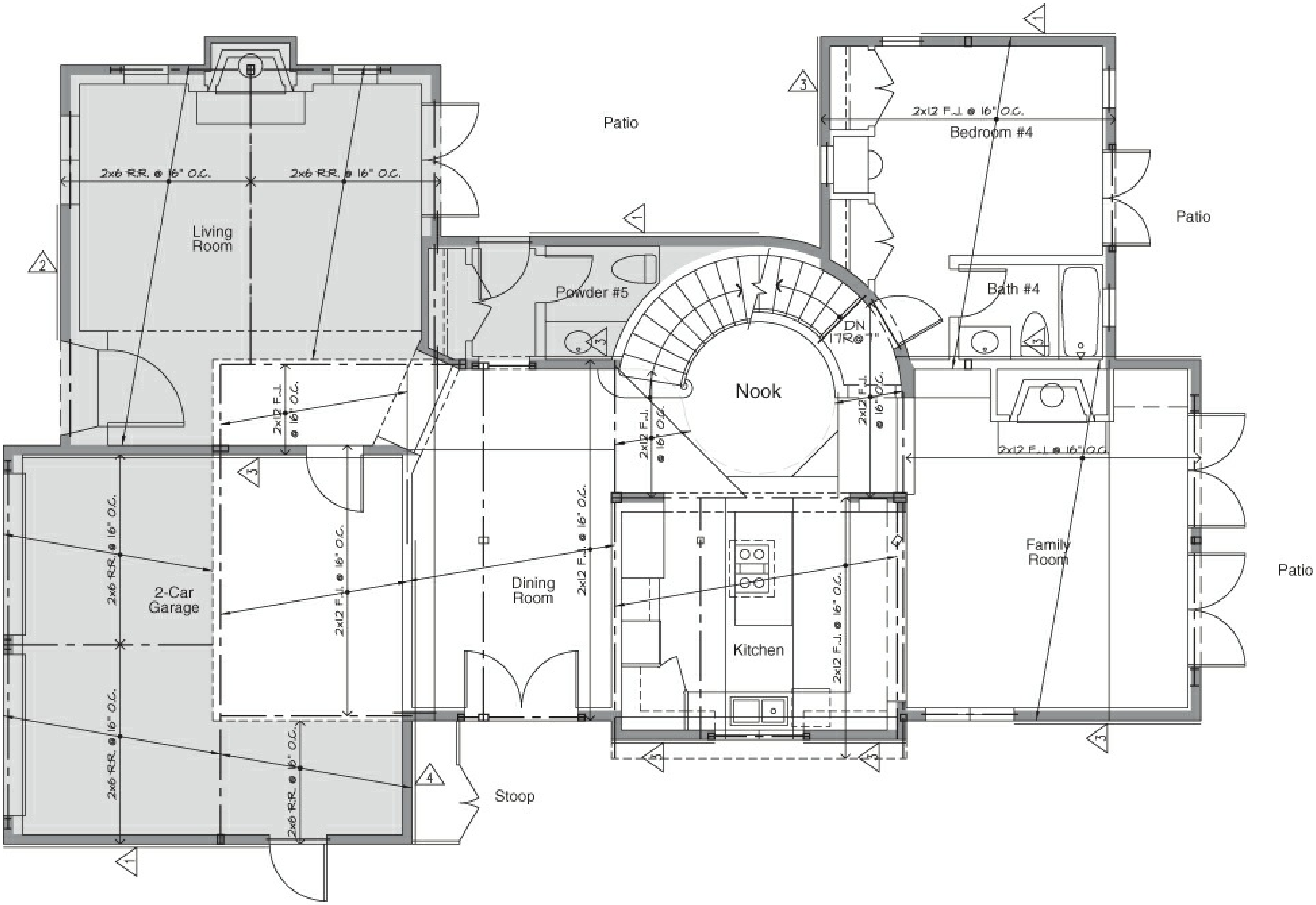
SYMBOL	PANEL	NAILING [8]	WALL	SOLE PLATE ATTACHMENT			TOP PLATE [4] ATTACHMENT	HOLDOWN [5,6]
		COMMON NAILS	LBS/FT	NAILS	LAGS [9]	ANCHOR BOLTS [6]		
1	3/8 EXPOSURE I [7] (ID#24/0)	8d @ 6,6,12	198	16d @ 6" O.C.	3/8" x 5" @ 24" O.C.	5/8" DIA. @ 48" O.C. 12" LONG	A35 @ 24" O.C.	HD2A, CB44, FTA2 PHD2
2 [1]	15/32 EXPOSURE I [7] (ID#32/16)	10d @ 4,4,12	299	16d @ 3.5" O.C.	3/8" x 5" @ 18" O.C.	5/8" DIA. @ 48" O.C. 12" LONG	A35 @ 16" O.C.	HD5A, CB44, FTA2 PHD5
3 [1,2,3] 3x SILL	15/32 EXPOSURE I [7] (ID#32/16)	10d @ 3,3,12	450	40d @ 3" O.C.	3/8" x 5" @ 12" O.C.	5/8" DIA. @ 32" O.C. 14" LONG	A35 @ 12" O.C.	HD6A, CB44, FTA5 PHD6
4 [1,2,3] 3x SILL	15/32 EXPOSURE I [7] STRUCT. I (ID#32/16)	10d @ 2,2,12	652	50d @ 3" O.C.	3/8" x 5" @ 8" O.C.	5/8" DIA. @ 24" O.C. 14" LONG	A35 @ 8" O.C.	HD8A, FTA7, PHD8

FOOTNOTES:

1. THESE PANELS TO BE 4-PLY MINIMUM.
2. 3x SOLE PLATES AND 3x FRAMING AT ADJOINING PANEL EDGES REQUIRED. STAGGER PANEL EDGE NAILING.
3. 1/2" MINIMUM EDGE DISTANCE REQUIRED FOR BOUNDARY NAILING.
4. A35'S NOT REQUIRED IF PANEL NAILS TO FRAMING MEMBER ABOVE TOP PLATES.
5. HOLDOWNS REQUIRED AT ENDS OF ALL SHEAR PANELS. USE 4x4'S FOR END MEMBERS. ALL HOLDOWN BOLTS TO BE TIGHTENED JUST PRIOR TO COVERING, INSPECTOR TO VERIFY. BOLT HOLES TO BE 1/16" MAXIMUM OVERSIZED AT THE CONNECTION OF THE HOLDOWN TO THE POST, INSPECTOR TO VERIFY.
6. SIMPSON BP WASHERS REQUIRED FOR ALL PLYWOOD SHEAR WALL SILL PLATE BOLTS AND HOLDOWN BOLTS.
7. OSB (ORIENTED STRAND BOARD) IS A WOOD STRUCTURAL PANEL.
8. SOLID BLOCKING SHALL BE PROVIDED AT ALL HORIZONTAL JOINTS OCCURRING IN BRACED WALL PANELS.
9. USE 3x BLOCKS AND 3x RIM JOISTS IF LAGS ARE USED.

Figure 9.97 Stage III: Structural support.

Stage IV (Figure 9.98). This stage shows the direction of the floor joist and its duration. A half arrowhead is used to indicate direction, and a full arrowhead indicates the duration. They are connected with a dot.



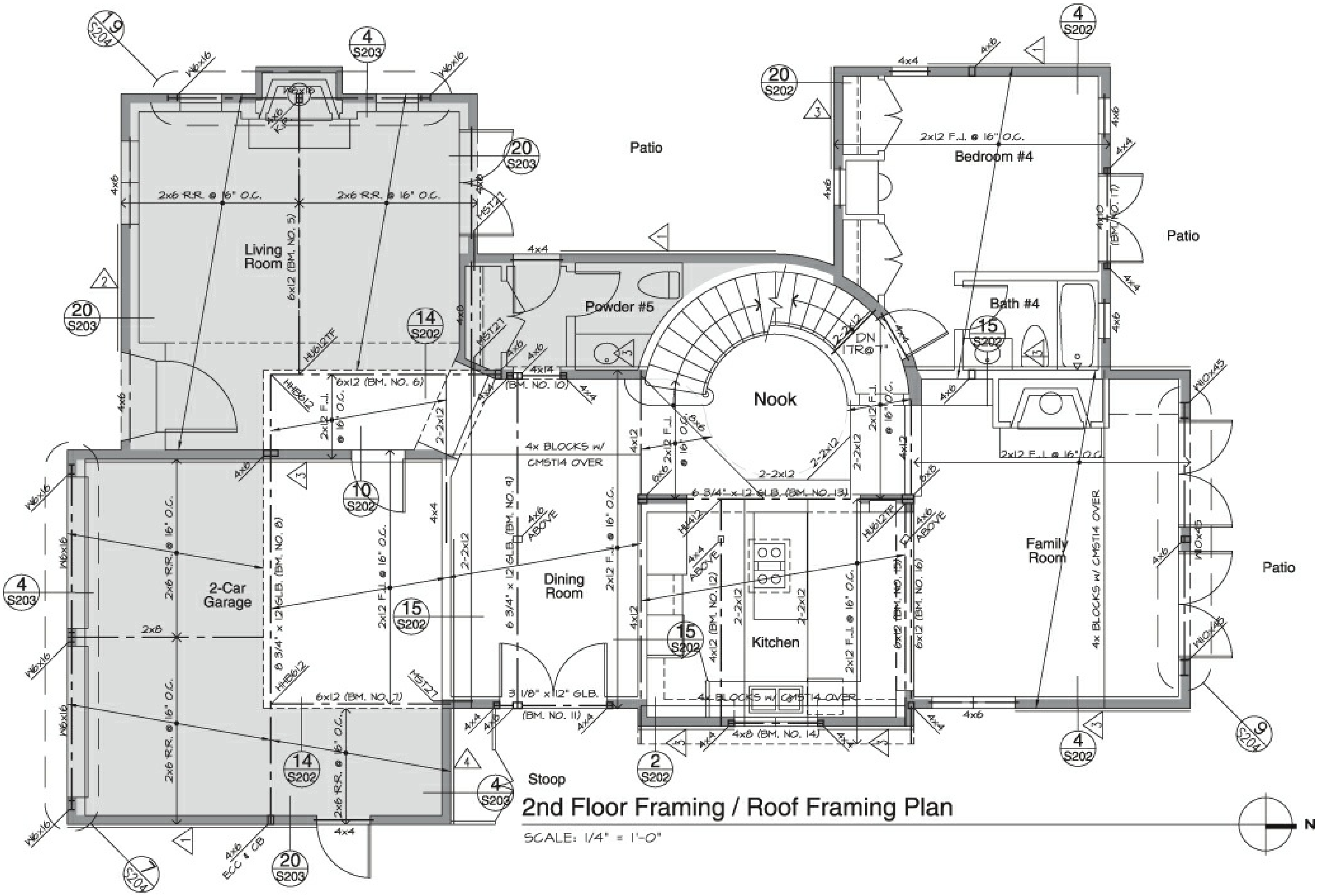
Shearwall Schedule

SYMBOL	PANEL	NAILING 8	WALL	SOLE PLATE ATTACHMENT			TOP PLATE 4 ATTACHMENT	HOLDOWN 5,6
		COMMON NAILS	LBS/FT	NAILS	LAGS 9	ANCHOR BOLTS 6		
1	3/8 EXPOSURE 1 7 (ID#24/0)	8d @ 6,6,12	198	16d @ 6" O.C.	3/8" x 5" @ 24" O.C.	5/8" DIA. @ 48" O.C. 12" LONG	A35 @ 24" O.C.	HD2A, CB44, FTA2 PHD2
2 1	15/32 EXPOSURE 1 7 (ID#32/16)	10d @ 4,4,12	299	16d @ 3.5" O.C.	3/8" x 5" @ 18" O.C.	5/8" DIA. @ 48" O.C. 12" LONG	A35 @ 16" O.C.	HD5A, CB44, FTA2 PHD5
3 1,2,3 3x SILL	15/32 EXPOSURE 1 7 (ID#32/16)	10d @ 3,3,12	450	40d @ 3" O.C.	3/8" x 5" @ 12" O.C.	5/8" DIA. @ 32" O.C. 14" LONG	A35 @ 12" O.C.	HD6A, CB44, FTA5 PHD6
4 1,2,3 3x SILL	15/32 EXPOSURE 1 7 STRUCT. 1 (ID#32/16)	10d @ 2,2,12	652	50d @ 3" O.C.	3/8" x 5" @ 8" O.C.	5/8" DIA. @ 24" O.C. 14" LONG	A35 @ 8" O.C.	HD8A, FTA7, PHD8

FOOTNOTES:
1. THESE PANELS TO BE 4-PLY MINIMUM.
2. 3x SOLE PLATES AND 3x FRAMING AT ADJOINING PANEL EDGES REQUIRED. STAGGER PANEL EDGE NAILING.
3. 1/2" MINIMUM EDGE DISTANCE REQUIRED FOR BOUNDARY NAILING.
4. A35'S NOT REQUIRED IF PANEL NAILS TO FRAMING MEMBER ABOVE TOP PLATES.
5. HOLDOWNS REQUIRED AT ENDS OF ALL SHEAR PANELS. USE 4x4'S FOR END MEMBERS. ALL HOLDOWN BOLTS TO BE TIGHTENED JUST PRIOR TO COVERING, INSPECTOR TO VERIFY. BOLT HOLES TO BE 1/16" MAXIMUM OVERSIZED AT THE CONNECTION OF THE HOLDOWN TO THE POST, INSPECTOR TO VERIFY.
6. SIMPSON BP WASHERS REQUIRED FOR ALL PLYWOOD SHEAR WALL SILL PLATE BOLTS AND HOLDOWN BOLTS.
7. OSB (ORIENTED STRAND BOARD) IS A WOOD STRUCTURAL PANEL.
8. SOLID BLOCKING SHALL BE PROVIDED AT ALL HORIZONTAL JOINTS OCCURRING IN BRACED WALL PANELS.
9. USE 3x BLOCKS AND 3x RIM JOISTS IF LAGS ARE USED.

Figure 9.98 Stage IV: Direction of joist and duration.

Stage V (Figure 9.99). In this stage, information as to size and space is filled in along the direction lines. Headers, beams, and columns are identified, along with the hardware and the connectors used. Referencing and titling complete the drawing.



Shearwall Schedule

SYMBOL	PANEL	NAILING [8]	WALL	SOLE PLATE ATTACHMENT			TOP PLATE ATTACHMENT [4]	HOLDOWN [5,6]
		COMMON NAILS	LBS/FT	NAILS	LAGS [9]	ANCHOR BOLTS [6]		
1	3/8 EXPOSURE 1 [7] (ID#24/0)	8d @ 6,6,12	198	16d @ 6" O.C.	3/8" x 5" @ 24" O.C.	5/8" DIA. @ 48" O.C. 12" LONG	A35 @ 24" O.C.	HD2A, CB44, FTA2 PHD2
2 [1]	15/32 EXPOSURE 1 [7] (ID#32/16)	10d @ 4,4,12	299	16d @ 3.5" O.C.	3/8" x 5" @ 18" O.C.	5/8" DIA. @ 48" O.C. 12" LONG	A35 @ 16" O.C.	HD5A, CB44, FTA2 PHD5
3 [1,2,3] 3x SILL	15/32 EXPOSURE 1 [7] (ID#32/16)	10d @ 3,3,12	450	40d @ 3" O.C.	3/8" x 5" @ 12" O.C.	5/8" DIA. @ 32" O.C. 14" LONG	A35 @ 12" O.C.	HD6A, CB44, FTA5 PHD6
4 [1,2,3] 3x SILL	15/32 EXPOSURE 1 [7] STRUCT. 1 (ID#32/16)	10d @ 2,2,12	652	50d @ 3" O.C.	3/8" x 5" @ 8" O.C.	5/8" DIA. @ 24" O.C. 14" LONG	A35 @ 8" O.C.	HD8A, FTA7, PHD8

FOOTNOTES:

1. THESE PANELS TO BE 4-PLY MINIMUM.
2. 3x SOLE PLATES AND 3x FRAMING AT ADJOINING PANEL EDGES REQUIRED. STAGGER PANEL EDGE NAILING.
3. 1/2" MINIMUM EDGE DISTANCE REQUIRED FOR BOUNDARY NAILING.
4. A35'S NOT REQUIRED IF PANEL NAILS TO FRAMING MEMBER ABOVE TOP PLATES.
5. HOLDOWNS REQUIRED AT ENDS OF ALL SHEAR PANELS. USE 4x4'S FOR END MEMBERS. ALL HOLDOWN BOLTS TO BE TIGHTENED JUST PRIOR TO COVERING, INSPECTOR TO VERIFY. BOLT HOLES TO BE 1/16" MAXIMUM OVERSIZED AT THE CONNECTION OF THE HOLDOWN TO THE POST, INSPECTOR TO VERIFY.
6. SIMPSON BP WASHERS REQUIRED FOR ALL PLYWOOD SHEAR WALL SILL PLATE BOLTS AND HOLDOWN BOLTS.
7. OSB (ORIENTED STRAND BOARD) IS A WOOD STRUCTURAL PANEL.
8. SOLID BLOCKING SHALL BE PROVIDED AT ALL HORIZONTAL JOINTS OCCURRING IN BRACED WALL PANELS.
9. USE 3x BLOCKS AND 3x RIM JOISTS IF LAGS ARE USED.

Figure 9.99 Stage V: Complete floor framing plan.

(Courtesy of James Orland, CE.)

Floor Framing above Masonry or Concrete

The graphic display of the floor framing on a masonry or concrete wall looks similar to the previously discussed roof framing plan, in that it also uses the same symbols and conventions. An example of a first…floor framing plan over a basement with walls made of concrete masonry units (CMUs) is shown in Figures 9.100 and 9.101.

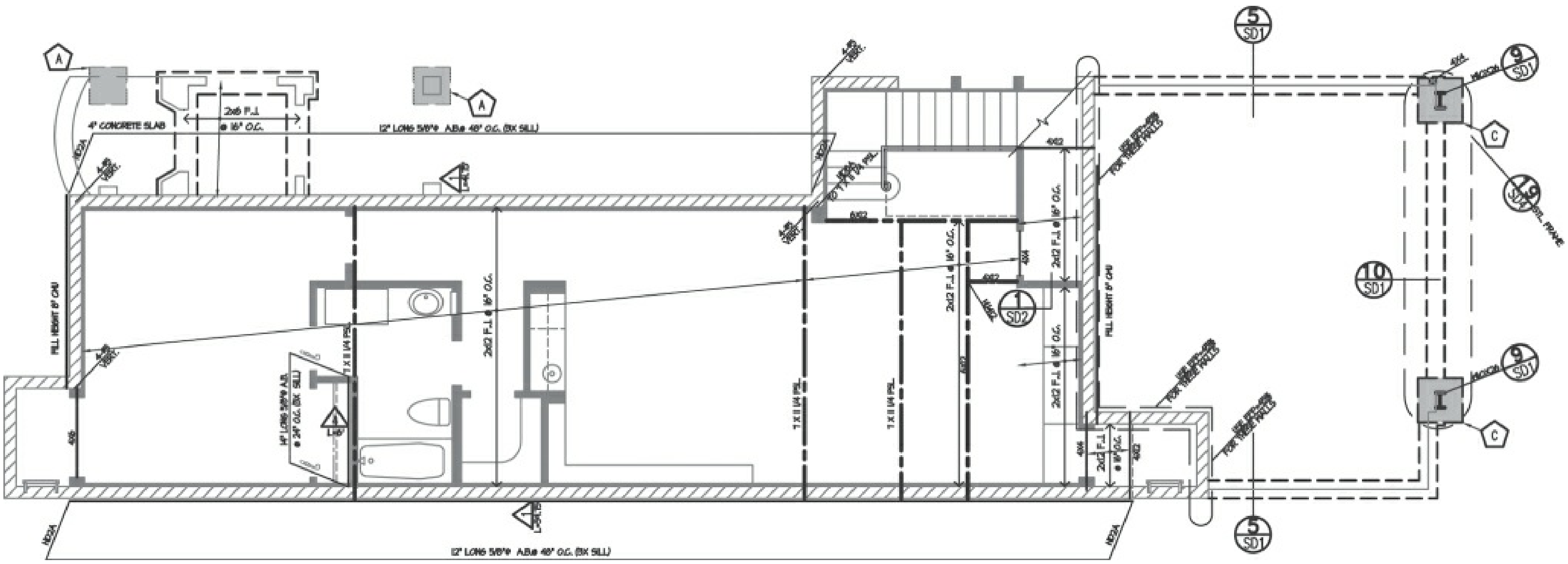


Figure 9.100 First…floor framing plan.

(Courtesy of Mr. & Mrs. Givens.)

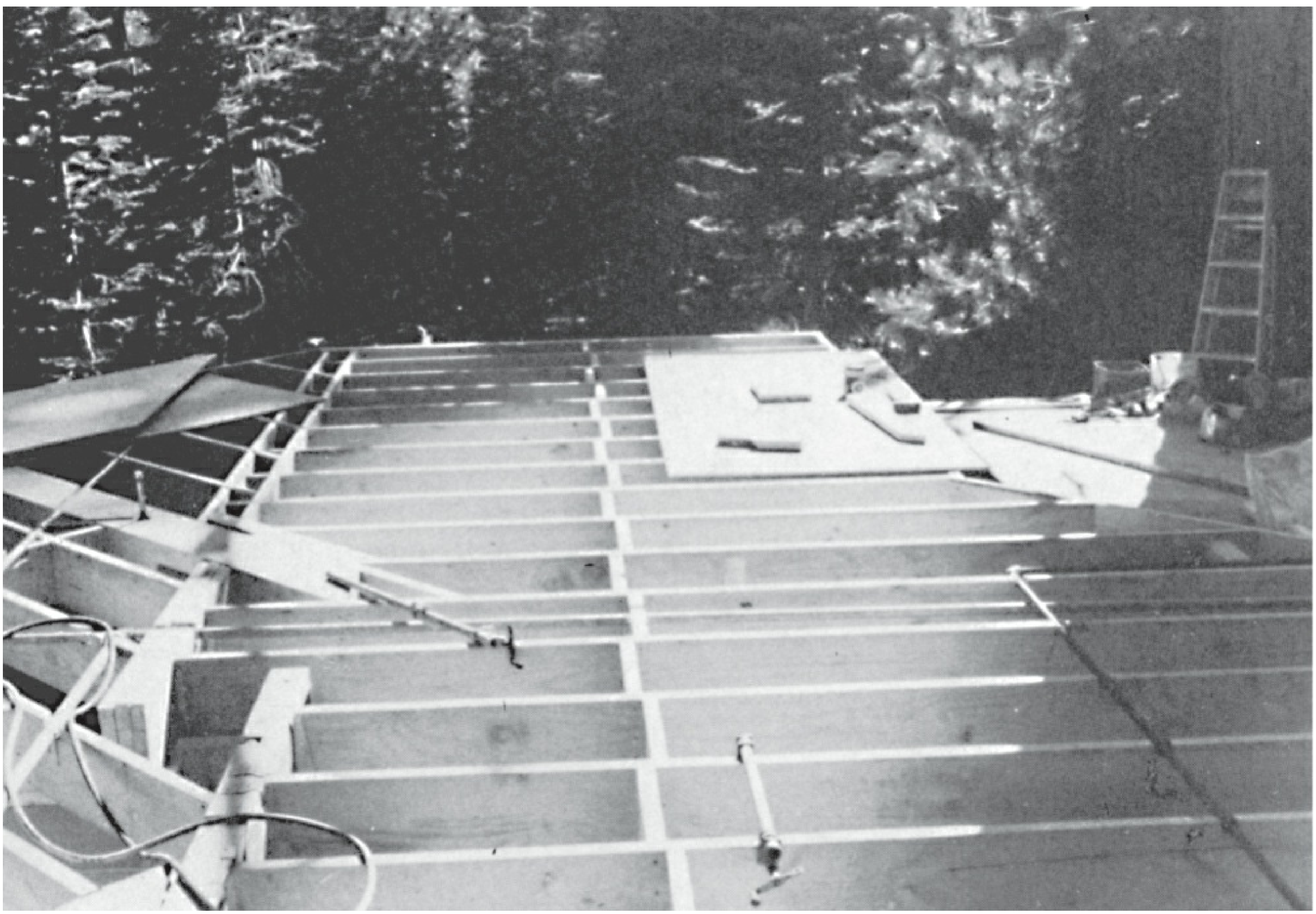


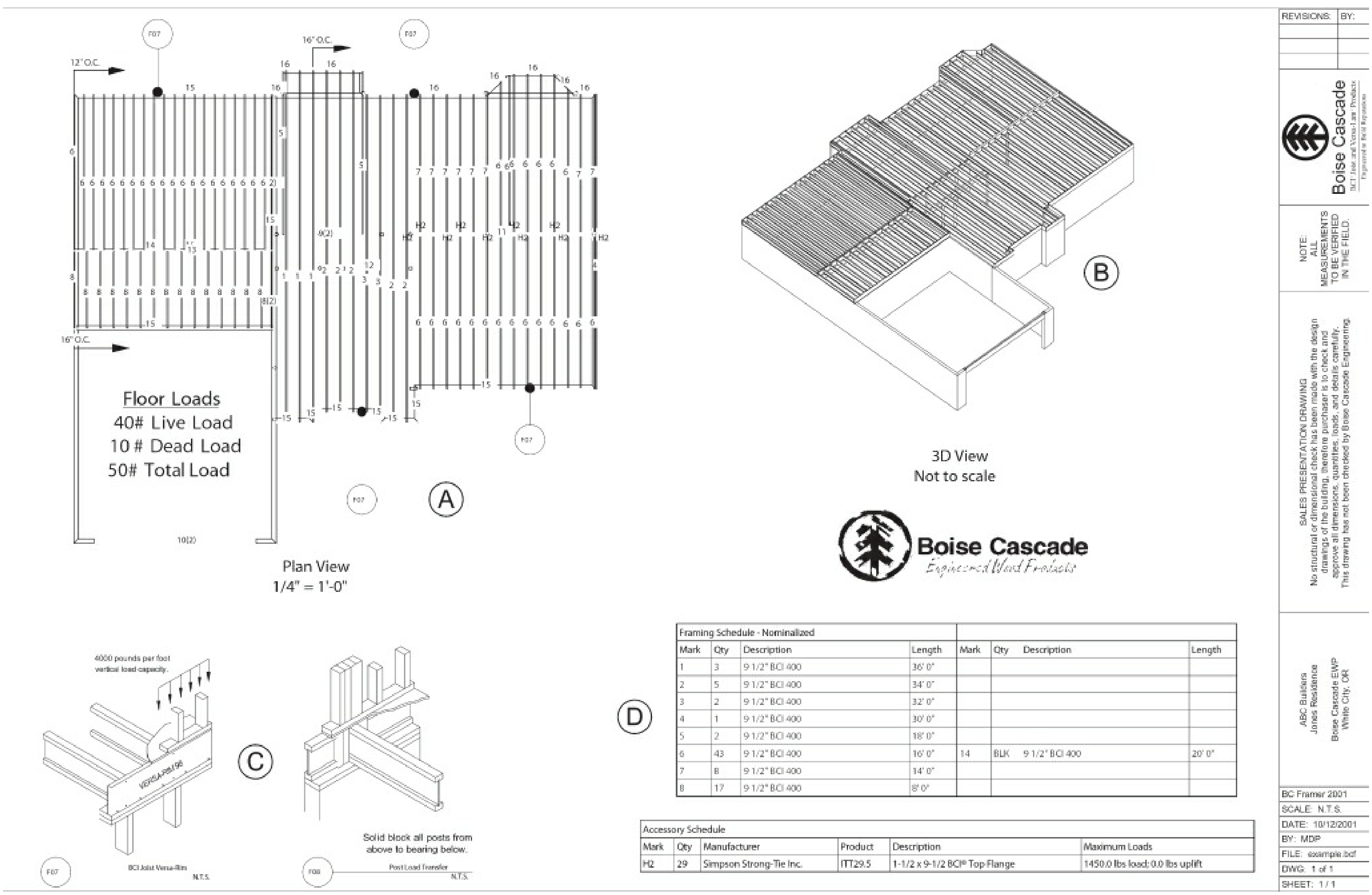
Figure 9.101 First‐floor framing.

Floor Framing Plan with Engineered Lumber

Rather than using the conventional method of framing described throughout this chapter, here we introduce the second‐floor framing system using engineered lumber. These drawings will become part of the structural set under normal circumstances, and not part of the architectural set of construction documents.

Normally, the first‐floor plan is sent to the manufacturer of the engineered lumber. For an example, we will use a plan drawn by Boise Cascade that utilizes the 9½″‐high Boise Cascade 400 series. This will be noted as 9–1/2BCI‐400.

The drawing is done by Boise Cascade drafters on a system similar to that of a standard AutoCAD program. The BC Framer, as it is called, reconciles the space allocated for the thickness of the floor determined by the designer, which is given to the manufacturer along with the floor plan. The manufacturer then takes the information provided by the office and translates it into the framing plan, as shown in Figure 9.102A. A pictorial of the assembly is shown in Figure 9.102B. Samples of the series of pictorial details are shown in Figure 9.102C, and a list of required materials and hardware appears in Figure 9.102D. A separate cost estimate is provided to the office, along with any engineering calculations required by the governing department of building and safety.



Framing Schedule - Nominalized

Mark	Qty	Description	Length	Mark	Qty	Description	Length
1	3	9 1/2" BCI 400	36' 0"				
2	5	9 1/2" BCI 400	34' 0"				
3	2	9 1/2" BCI 400	32' 0"				
4	1	9 1/2" BCI 400	30' 0"				
5	2	9 1/2" BCI 400	18' 0"				
6	43	9 1/2" BCI 400	16' 0"	14	BLK	9 1/2" BCI 400	20' 0"
7	8	9 1/2" BCI 400	14' 0"				
8	17	9 1/2" BCI 400	8' 0"				

Accessory Schedule

Mark	Qty	Manufacturer	Product	Description	Maximum Loads
H2	29	Simpson Strong-Tie Inc.	ITT29.5	1-1/2 x 9-1/2 BCI® Top Flange	1450.0 lbs load; 0.0 lbs uplift

Figure 9.102 Drawing by BC Framer.

(Courtesy of Boise Cascade, Timber & Wood Products Division.)

The service is total and makes the preparation of framing plans a delight for the architectural office. However, the senior drafters must be able not only to read the framing plans, but also to ensure their proper integration with the rest of the drawings. The drafters must also initially consider the space that must be provided for any overlooked items: duct space for heating and air…conditioning units; space for venting appliances such as ranges and water heaters; space for electronic appliances and access for electrical lines from the fixtures to the computers and for the drainpipes that run from the roof through the floors and walls. All of these matters should be resolved before you submit the plans for framing drawings. Such thoroughness will also provide the workers in the field with a clear picture of potential problems that can be averted. This is further accomplished with comprehensive details, partial sections, and full sections.

CASE STUDIES: WORKING DRAWING DEVELOPMENT

In this section, we discuss the development of the roof plans, floor framing, and roof framing working drawings for the Clay Theater steel and masonry building (Chapter 18).

Clay Theater—Steel/Masonry Structure

Roof Plan. Review the first…floor plan, the upper…floor plan, the sections, and the preliminary elevations before starting to study this roof plan.

Stage I

First, we traced the roof plan from the first…floor plan. See Figure 9.103. The dotted lines located the major interior walls. Note that the design called for the exterior walls to extend above and beyond the tops of the roof. The five major divisions of the roof are the top, bottom, left, right, and center. The top, bottom, left, and right portions all slope away from the structure. The center portion slopes in two directions with a ridge at the center.

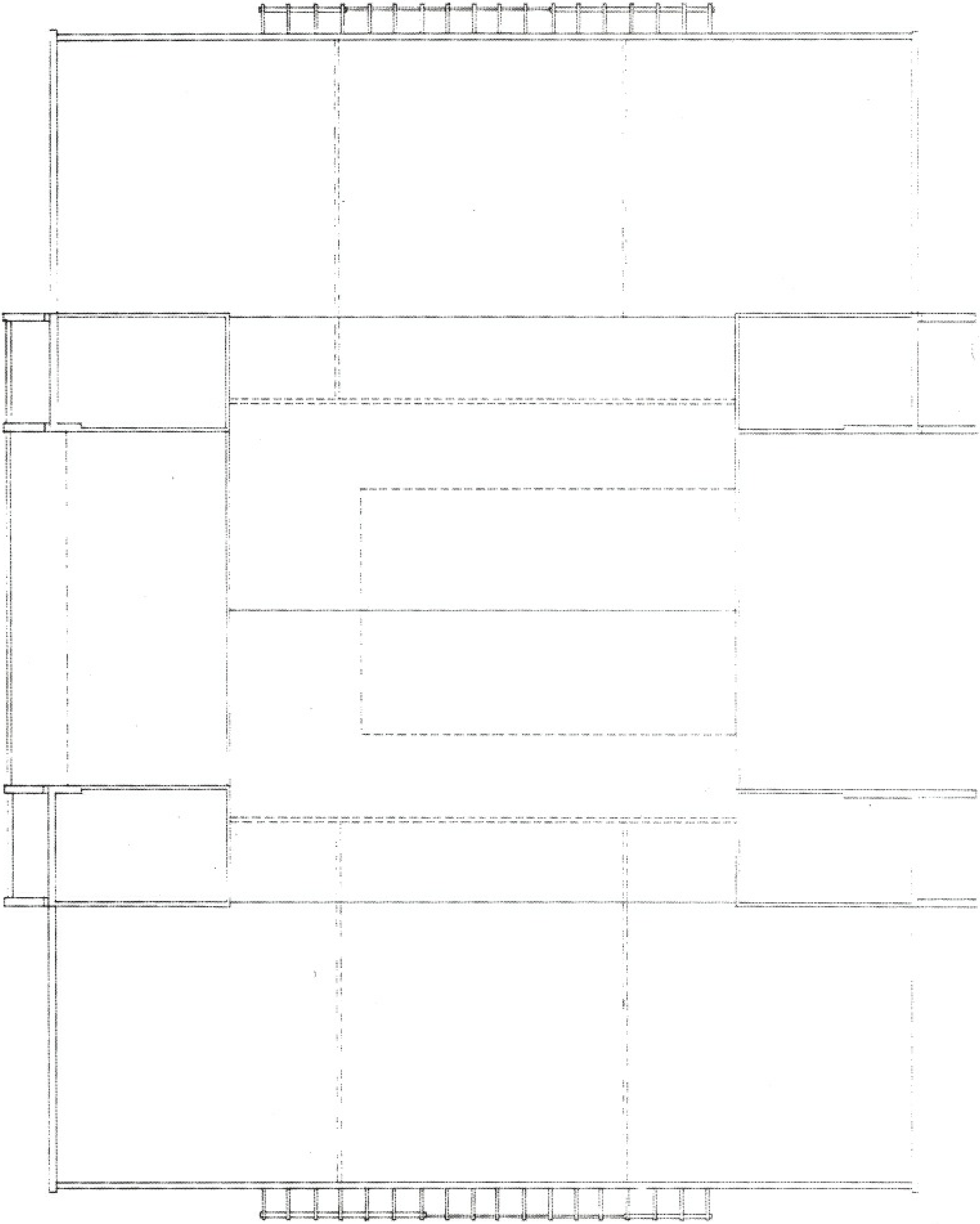


Figure 9.103 Clay Theater—Stage I: Working drawing—roof plan.

Because the four major portions around the center rose higher than the center, roof

drains were required. See Figure 9.104. These drains and the surrounding areas will be mentioned later. The exterior walls in Figure 9.103 were drawn slightly wider than the interior walls because they represented exterior plaster over concrete block. Note the configuration of the arbor over the exterior exits from each auditorium.

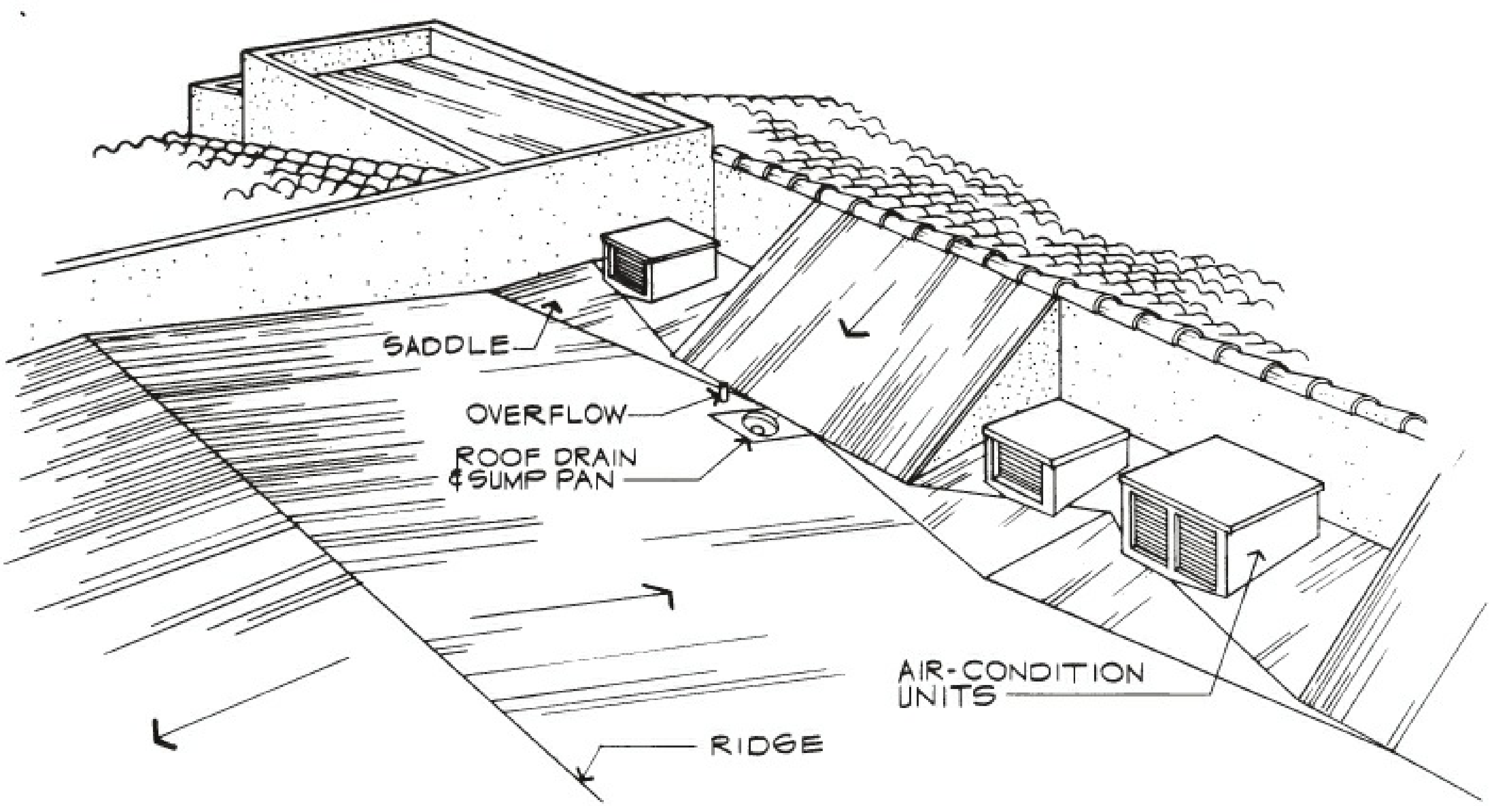


Figure 9.104 Corner of central portion of roof.

Stage II

To better understand this roof, as shown in Figure 9.105, look at the sketch of its central portion in Figure 9.104. The line at the very center is the ridge. This ridge produces a gable…type roof at the central portions. The surrounding portions are higher and so the slope of this gable roof needs to be drained at its edges. Roof drains, commonly called scuppers, were added at strategic points. As you can see by comparing the sketch with the plan, portions of the low point of the gable roof remained flat to accept air…conditioning equipment. Other portions sloped down from the vertical plane like a shed roof. Sheet metal saddles, called crickets, were positioned to control the flow of water on the roof and to direct it toward the roof drains. The small circles near the roof drains represent the overflow drains provided in case the regular scuppers clog. On two sides of the structure, we added reference bubbles to correspond with those on the plans and sections.

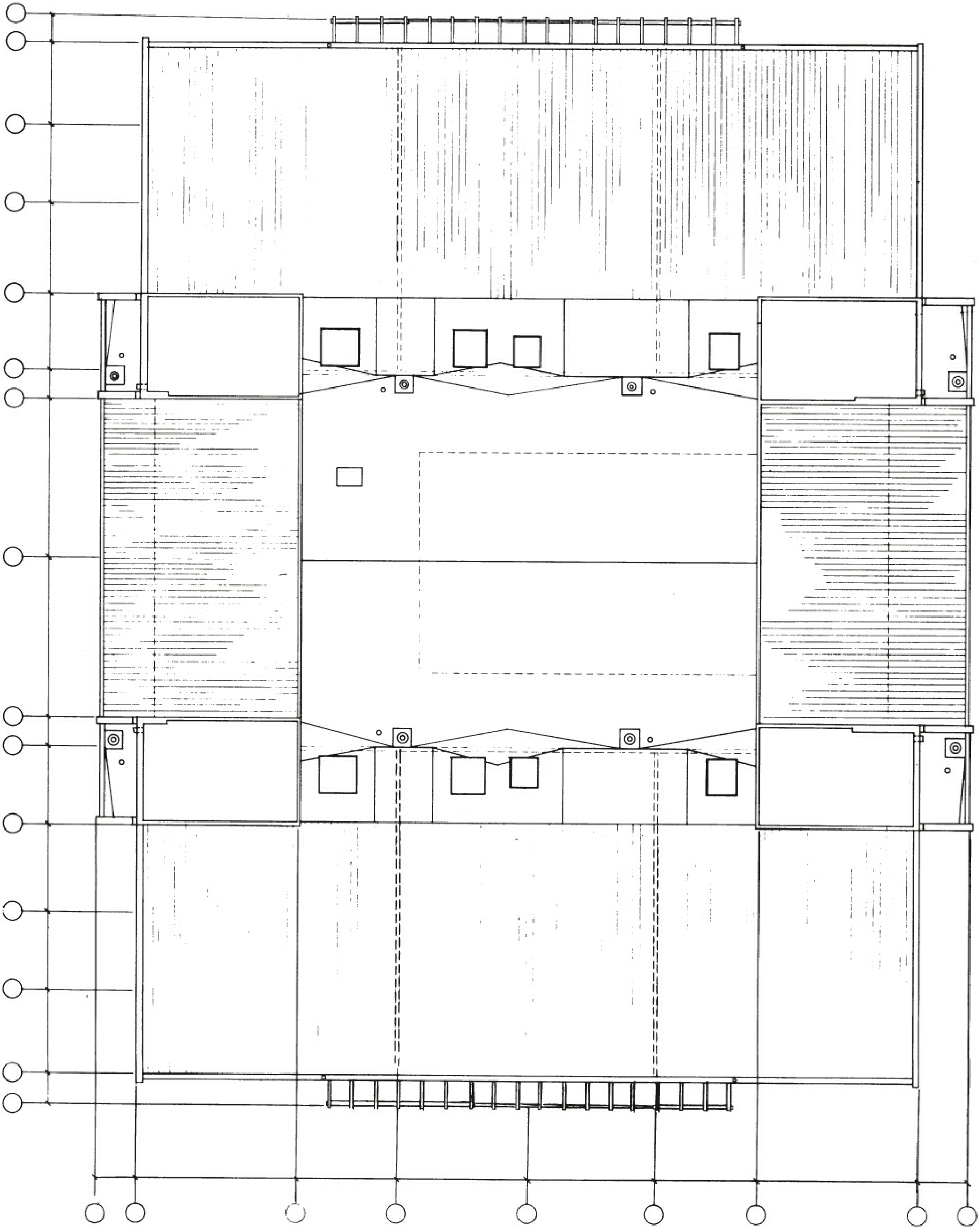


Figure 9.105 Clay Theater—Stage II: Working drawing—roof plan.

Stage III

At this stage, the reference bubbles were numbered and lettered. See Figure 9.106. Numerical values for all the dimension lines were added next. The slopes of the roofs were designated by arrows. Arrows at the edges of the roof show the slope of the gutters toward the downspout.

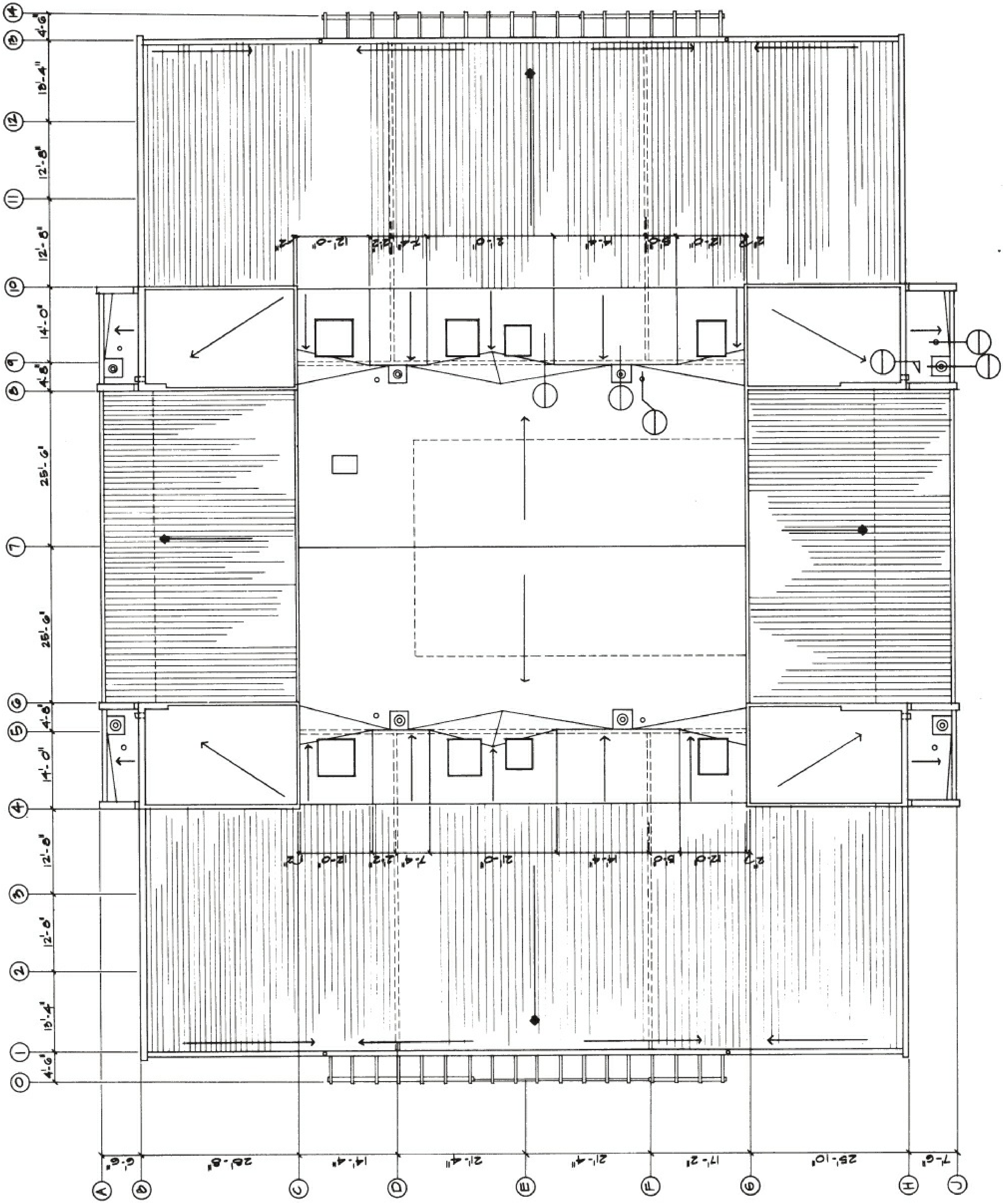


Figure 9.106 Clay Theater—Stage III: Working drawing—roof plan.

All dimensions were verified with the building section in this chapter, and the

engineering drawings were checked for correct column and beam locations. Finally, detail reference bubbles were drawn. The details were selected at an earlier stage.

Roof Framing Plan. When you are using steel members to support ceilings, floors, and roof, show all the members on the framing plans. The method of drawing the framing plan is similar to the method for drawing wood framing plans.

After you have selected a method, draw the steel members with a heavy single line. See Figure 9.107, which is a roof framing plan for a theater using various…size steel members and steel decking. The interior walls have been drawn with a broken line, which distinguishes the heavy solid beam line and the walls below. As you can see, all the various beam sizes are noted directly on the steel members. Some members have an abbreviated “DO” as their call…out; this tells the viewer that this member is identical to the one noted in the same framing bay.

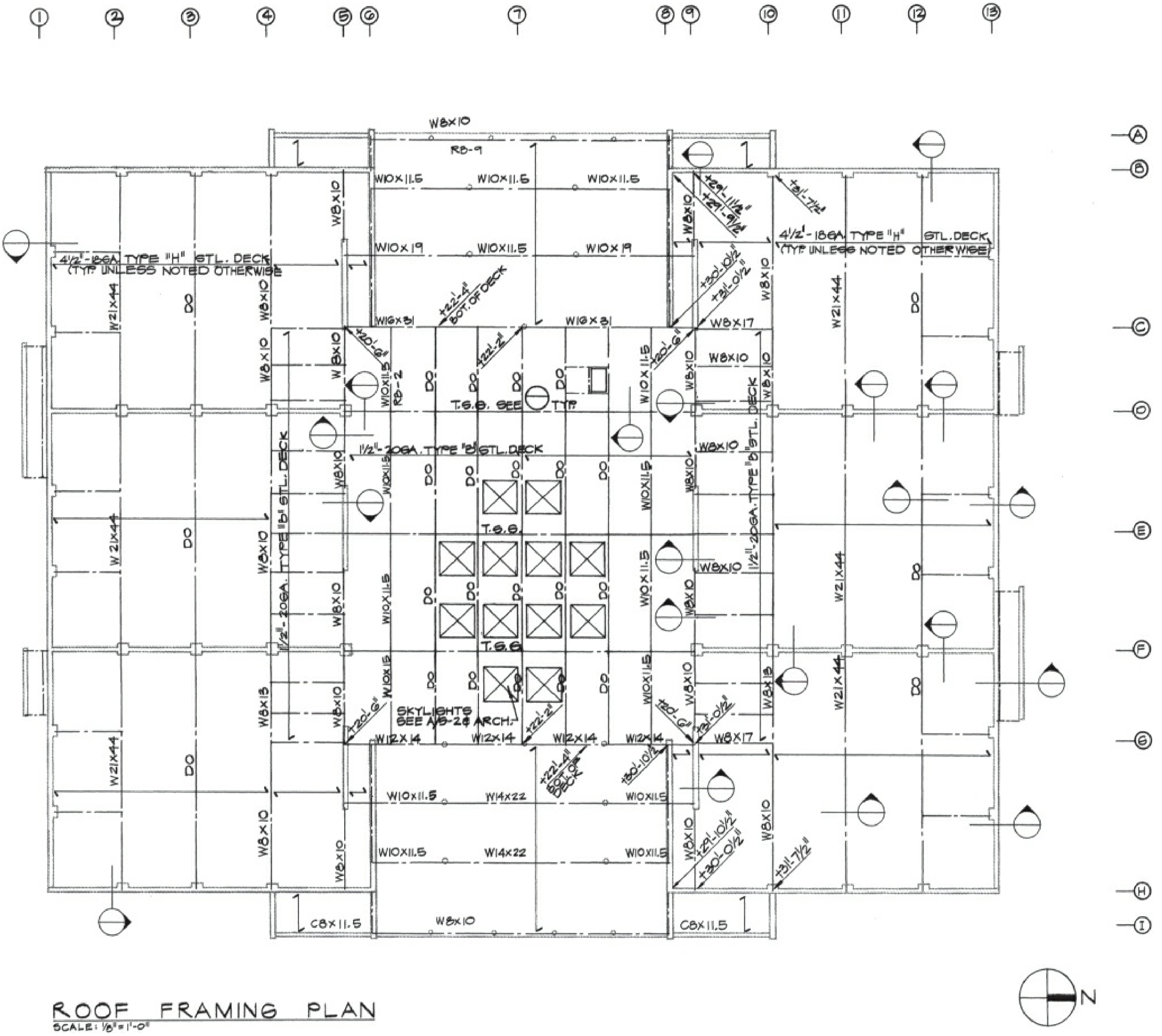


Figure 9.107 Clay Theater—roof framing plan: Steel members.

In some cases, a beam may also be given a roof beam number, noted as “RB…1,” “RB…2,” and so on. The structural engineer uses this beam reference in the engineering calculations. It can also be incorporated into a roof beam schedule, if one is needed. Any elements that require openings through a roof or floor should be drawn directly on the plan. In Figure 9.85, an open area for skylights and a roof access hatch are shown with a heavy solid line.

A framing plan can also be useful to show detail reference symbols for connections of various members that cannot otherwise be shown on the building sections. Figure 9.107 shows several detail symbols for various connecting conditions. Show building section reference symbols at their specific locations.

Axial reference lines form the basis for dimensioning steel framing members. These lines provide a reference point for all other dimensioning. Axial reference symbols are shown on all the major beam and wall lines. From these, subsequent dimension lines to other members are provided. These same reference lines are used on the foundation plan.

Beam and column elevation heights are often shown on the framing plan. See the axial reference point H…10 in Figure 9.107. The diagonal line pointing to this particular beam has an elevation height of 31′…7½″ noted on the top of the diagonal line. This indicates the height to the top of the beam. If the height at the bottom of that beam were required, you would note it underneath the diagonal line. Columns usually only require the elevations to the top of the column.

An aerial photograph showing a stage of the roof framing is shown in Figure 9.108. You can clearly see the main supporting steel members, as per axial reference lines 3, 4, 10, 11, and 12, and some placement of the steel decking on top of these members.

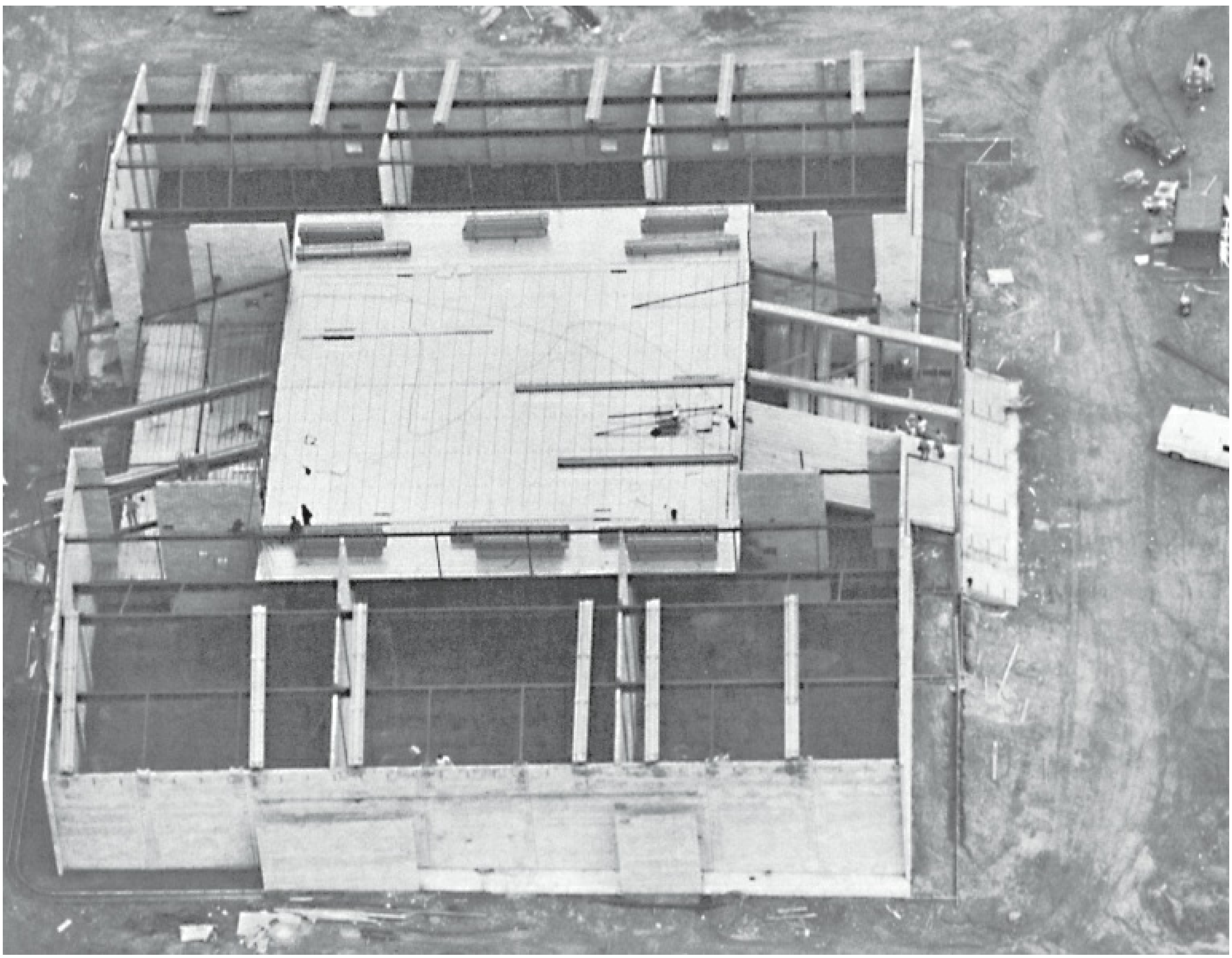


Figure 9.108 Clay Theater roof framing.

Framing Plan: Wood and Steel Members. Framing plans using both wood and steel

members to support ceilings, floors, and roof are drawn in a similar fashion to framing plans using steel alone. Steel members are drawn with a heavy solid line and the wood members with a lighter line broken at intervals. You can also show wood members with a solid line and directional arrow.

Figure 9.109 shows a floor framing plan using steel and wood members to support the floor. This particular building is supported mainly on round steel columns, with the wall being used only to enclose a lobby and stairwells. For clarity, draw these columns in lines, and be careful to align them with each other. After you have laid out the required columns and walls below, draw in the main steel members with a solid heavy line. The designation of floor trusses spaced at 24″ on centers is shown between these steel members.

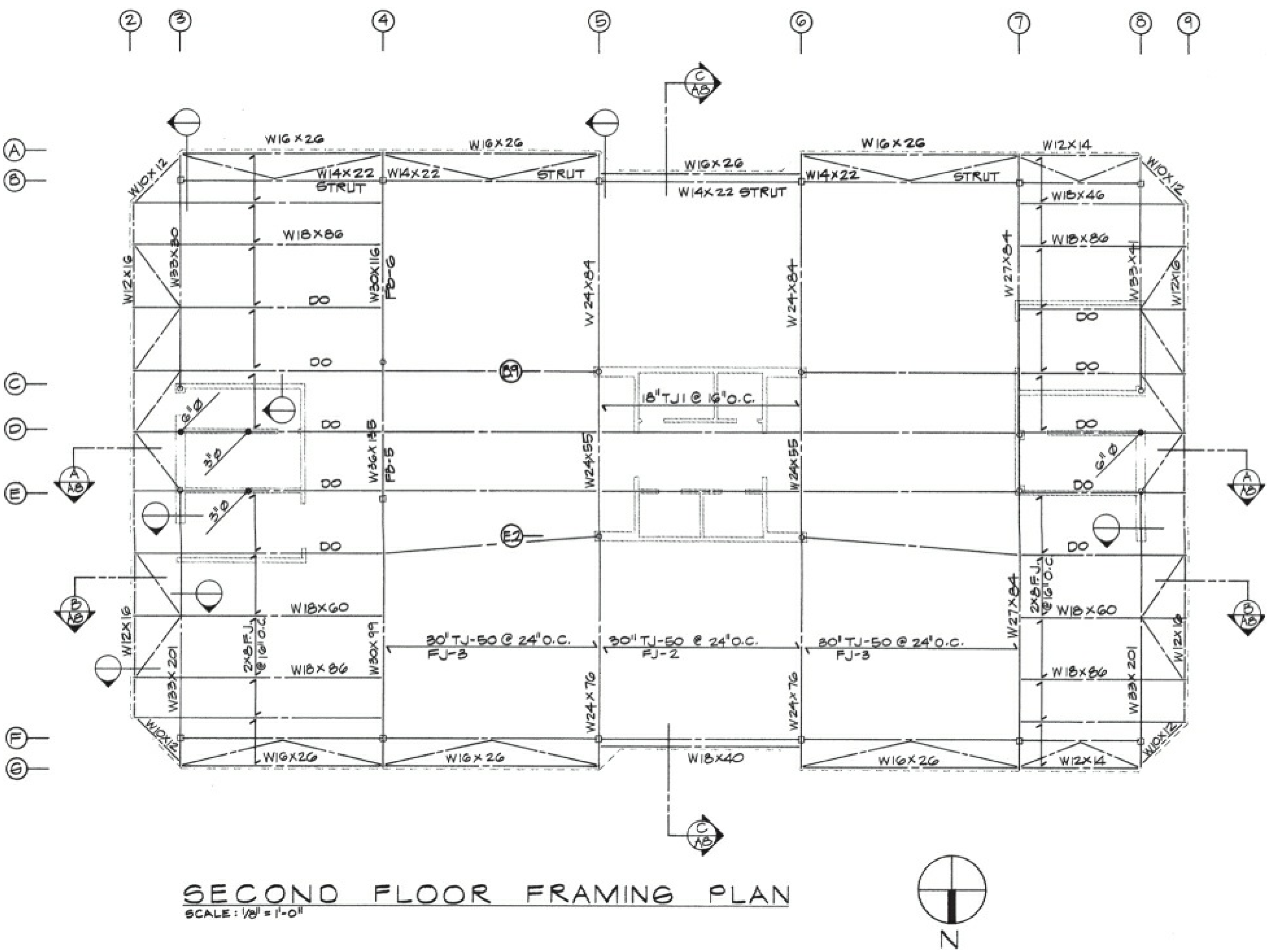


Figure 9.109 Framing plan: Second floor.

Because these members are closely spaced, a solid line is used with directional arrows at the end and the size and spacing of trusses are noted directly above the solid line. The bottom of the line shows the notation "FJ…3." This is the abbreviation for floor joist number 3, which is referenced in the structural engineer's calculations and may be used

in a floor joist schedule. When you are asked to draw a similar framing plan, be sure to show the joist for all bay conditions. As we saw earlier, “DO” is shown between axial reference lines (7) and (8). When you use this abbreviation, be sure it is clear. Detail reference symbols are shown for the connections of various members. Sizes and shapes for all the steel columns have been designated, as has the elevation height to the top of each column. Building section reference symbols and locations are shown. Whenever possible, take these sections directly through an axial reference plan.

Dimensioning for this type of project relies totally on axial reference planes as they relate to the column locations. Usually, you should locate notes satisfying various requirements on this same drawing. For example, these notes might designate the thickness, type, and nailing schedule for the plywood subfloor or the location of the fire draft stops within the floor framing.

To understand this structure better, look at the series of framing photographs. Figure 9.110 is a close…up view of a main steel floor beam and column with joist hangers located at the top of the beam in preparation for attachment of the floor truss members.

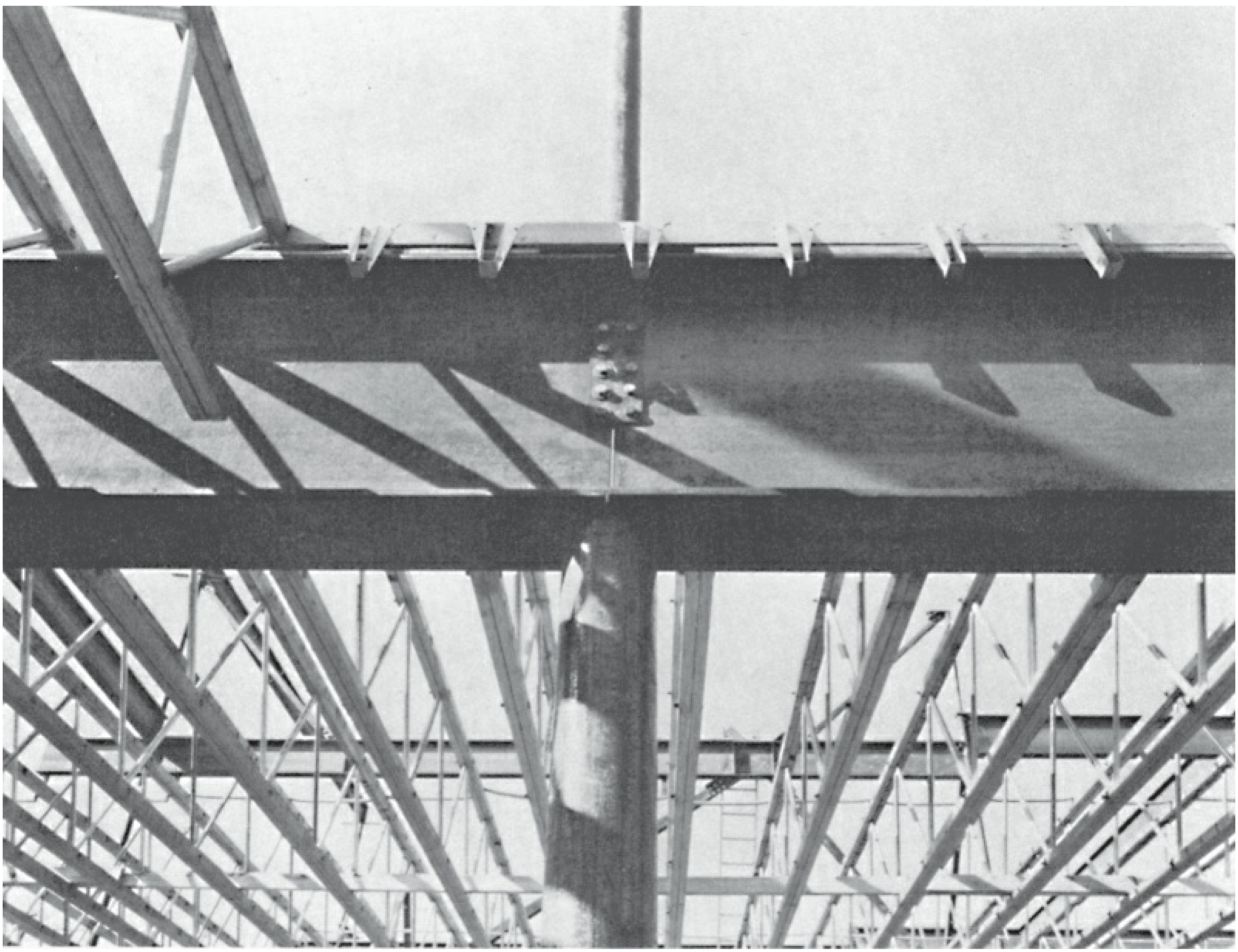


Figure 9.110 Clay Theater—main steel floor beam and column with joist hangers.

In Figure 9.111 floor joist trusses have now been attached to the hangers and nailed in place. Reference symbols for connection details should be located throughout the framing plan drawings. Figures 9.112 and 9.113 give examples of what these details may look like during the actual construction phase.

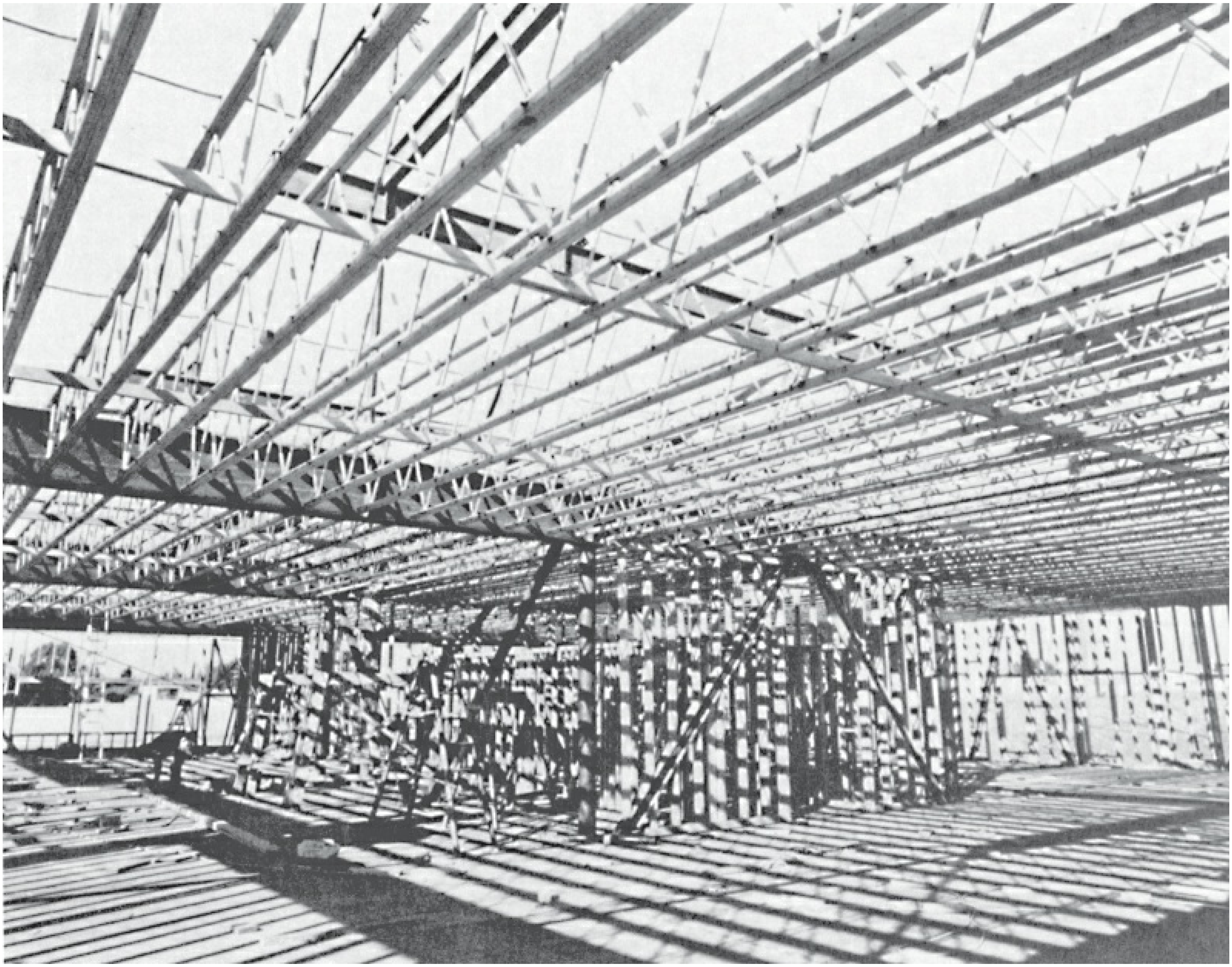


Figure 9.111 Clay Theater—floor joist trusses attached to hangers and nailed in place.

(Courtesy of Westmount, Inc., Real Estate Development; William Boggs Aerial Photography. Reprinted with permission.)

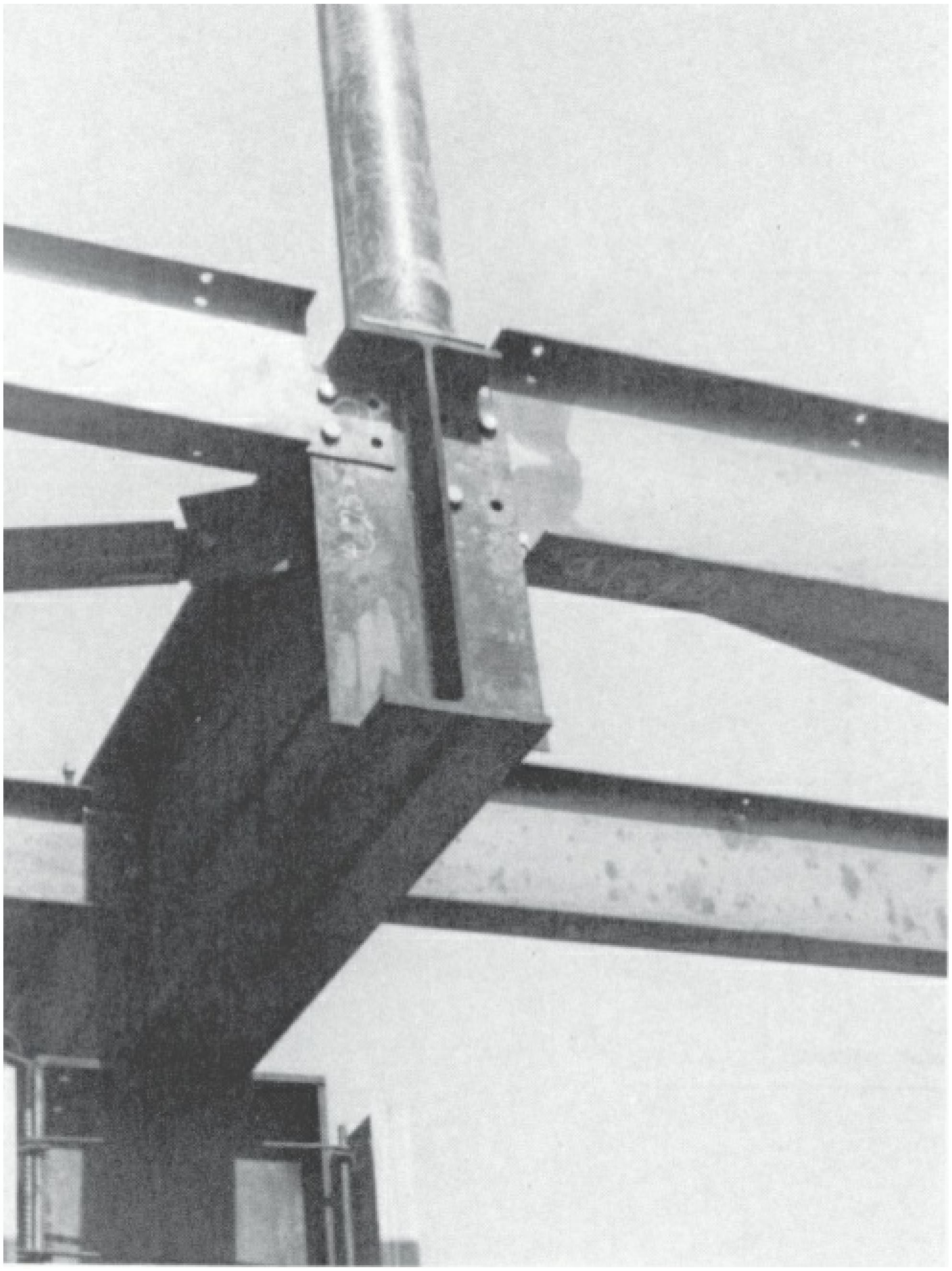


Figure 9.112 Clay Theater—beam and column connection.

(Courtesy of Westmount, Inc., Real Estate Development.)

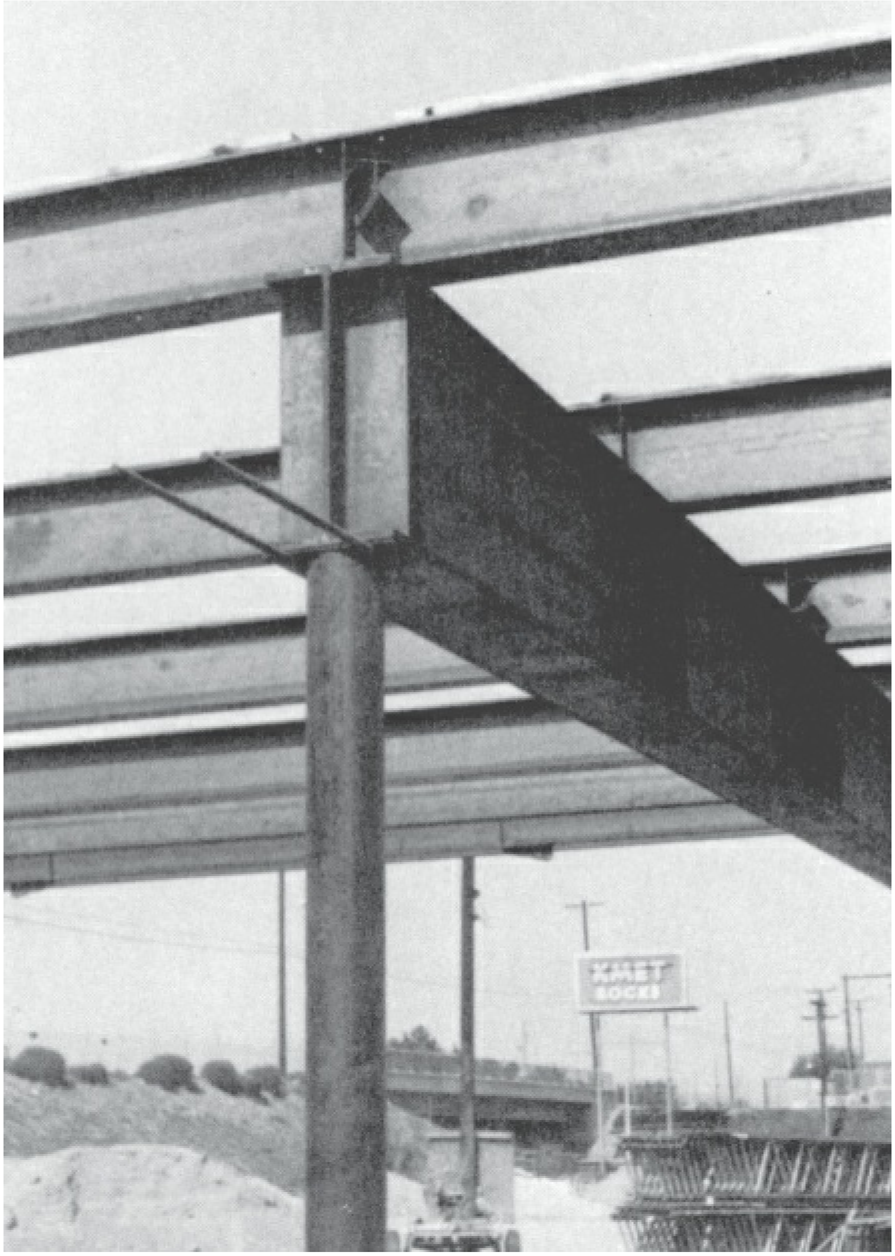


Figure 9.113 Clay Theater—floor beam to main beam assembly.

(Courtesy of Westmount, Inc., Real Estate Development.)

Framing Plan Checklist

1. Titles and scales.
2. Indicate bearing and non…bearing walls.
    a. Coordinate with foundation plan.
    b. Show all openings in walls.
3. Show all beams, headers, girders, purlins, etc.
4. Show all columns; note sizes and materials.
5. Note roof access way to attic—if occurs.
6. Note ceiling joist sizes, direction, spacing.
7. Draw all rafters; note sizes and spacing.

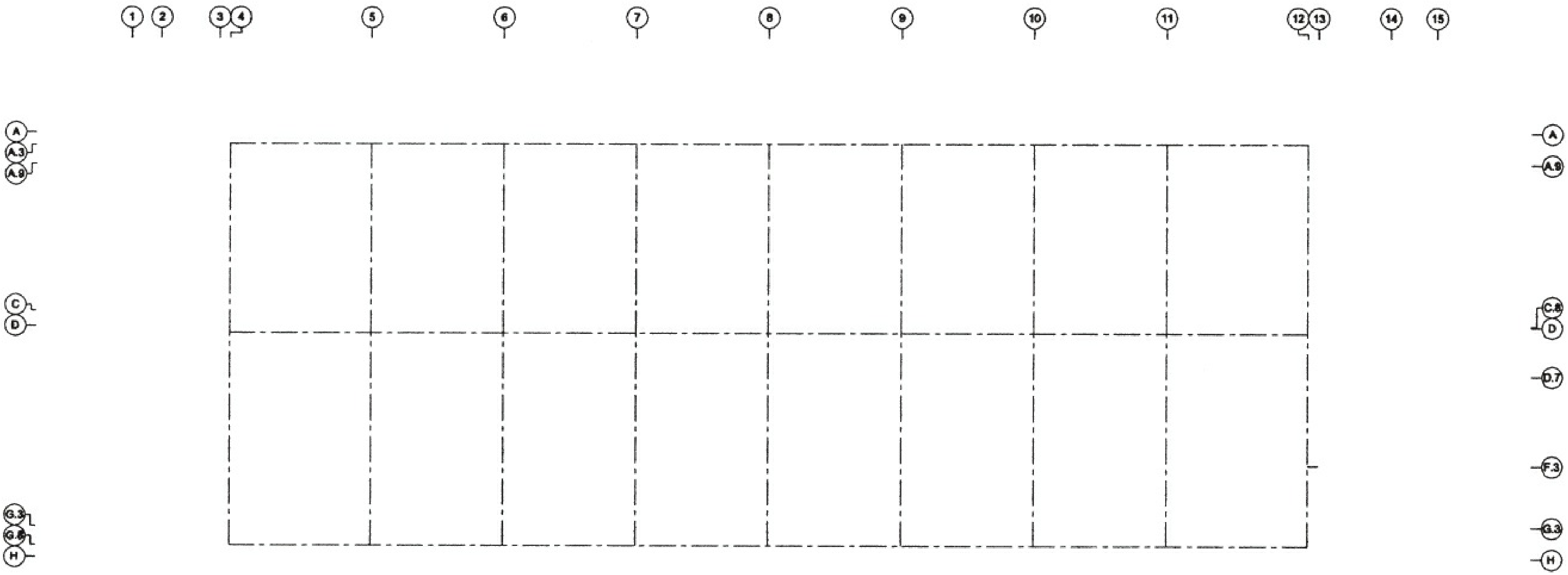
   a. Show skylight penetrations.
   b. Show chimney penetrations.
8. Draw overhangs.
   a. Indicate framing for holding overhangs up.
   b. Dimension width of footings.
9. Note shear walls and length of wall.
10. Note roof sheathing type, thickness, and nailing.
11. Indicate all ridges and valleys. Note sizes.
12. Note all differences in roof and floor levels.
13. Provide all shear schedules.
14. Provide material specifications.
15. Provide nailing schedule.
16. Note structural observation requirements.

Madison—Steel Building

Third_Floor Framing Plan

Stage I

The first step in developing the third…floor framing plan is to recall the matrix layout that originally identified the locations of the columns and beams in the building. The matrix layout used for Stage I of the third…floor framing plan is an amended portion of the matrix layout found in Figure 9.114. The initial matrix for the third…floor framing plan deals with the matrix symbols 4 through 12 and A/3 through G/8. Lettering identifying the third…floor framing plan and the scale of the drawing are also shown at this time. This matrix drawing identifying the column and beam locations is depicted in Figure 9.114.

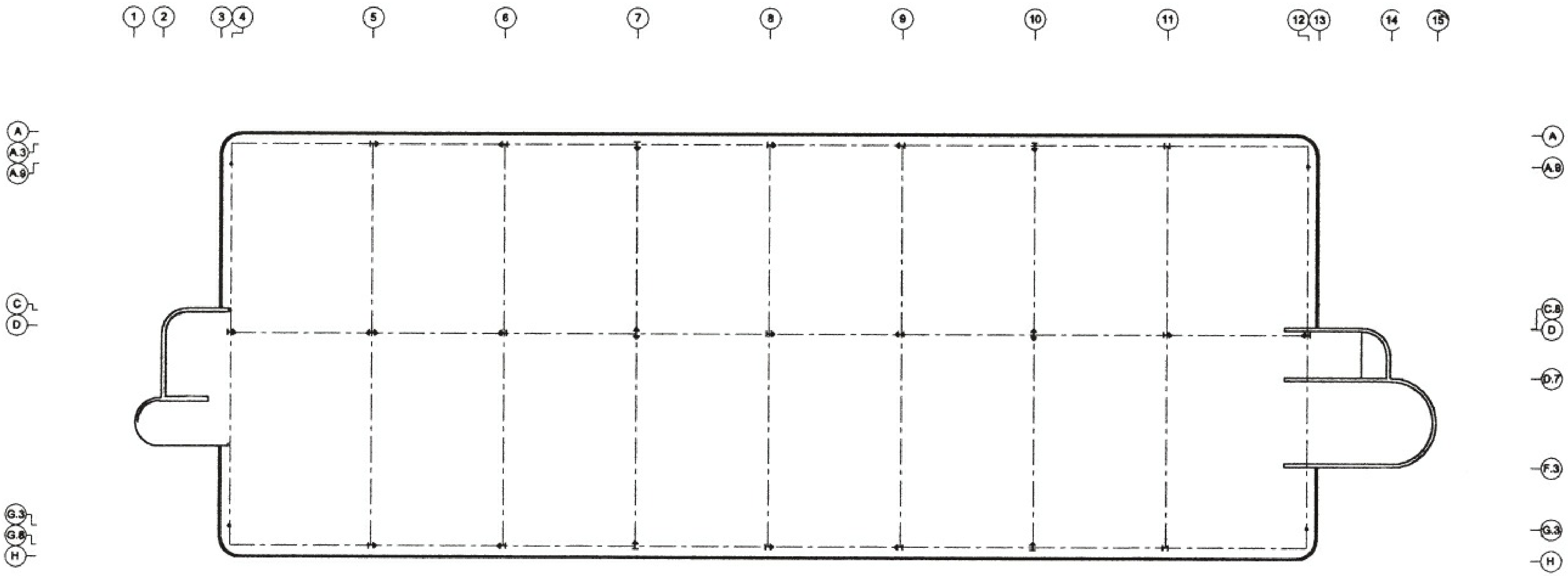


Third Floor Framing Plan

Figure 9.114 Madison Building—Stage I: Working drawing—third…floor framing plan.

Stage II

Using the first…stage drawing as the basis for the Stage II drawing, the perimeter exterior wall lines are drawn along with the exterior wall configurations of the stairwells and the lobbies. Also included in this drawing are the supporting column locations. These are shown at the perimeter walls and the main supporting center beam along the matrix line D. This drawing is illustrated in Figure 9.115.

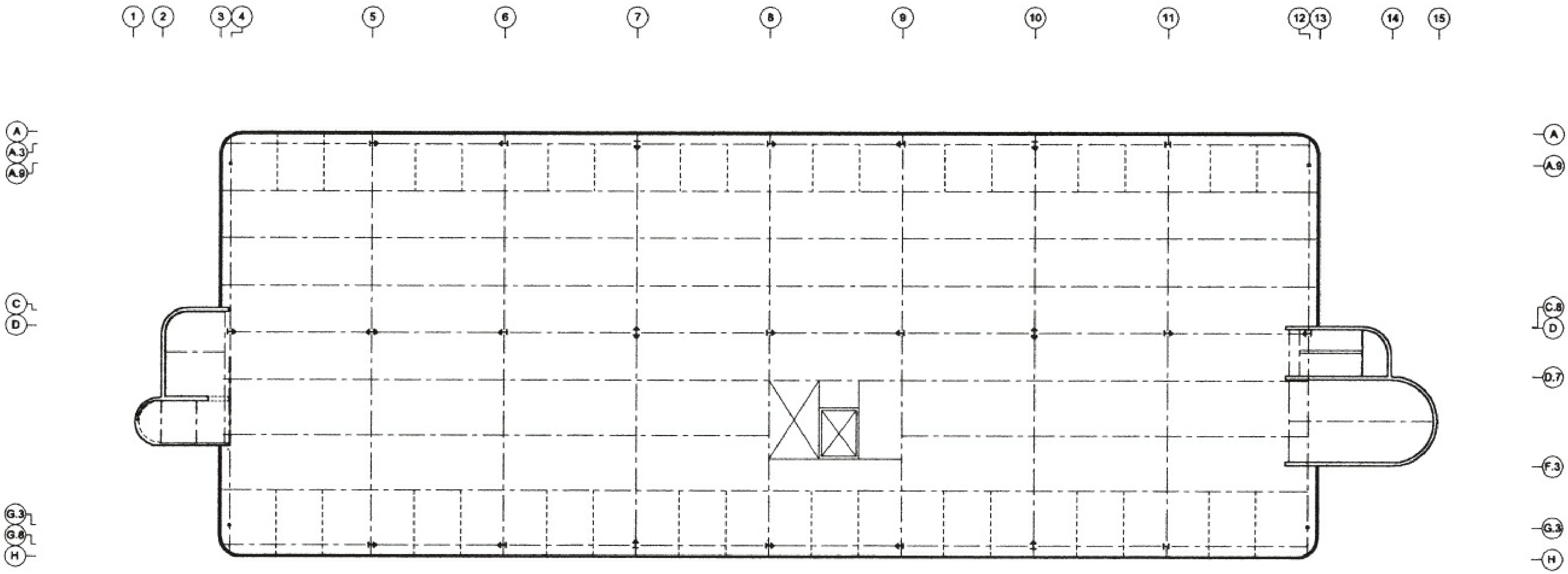


Third Floor Framing Plan

Figure 9.115 Madison Building—Stage II: Working drawing—third…floor framing plan.

Stage III

Prior to the completion of the drawing for Stage III, the drawings of Stages I and II are sent to the consulting structural engineer for his or her use in developing the engineering calculations and the required intermediate beam locations. Required beams have also been shown in the stairwell and lobby areas. Framing members that provide the opening around the elevator are also shown. It should be noted at this stage that because this is an all…structural…steel building, the intermediate structural members spanning between the main north/south members have been spaced to receive a corrugated steel decking with a hard…rock concrete topping. Figure 9.116 illustrates Stage III for the third…floor framing plan.

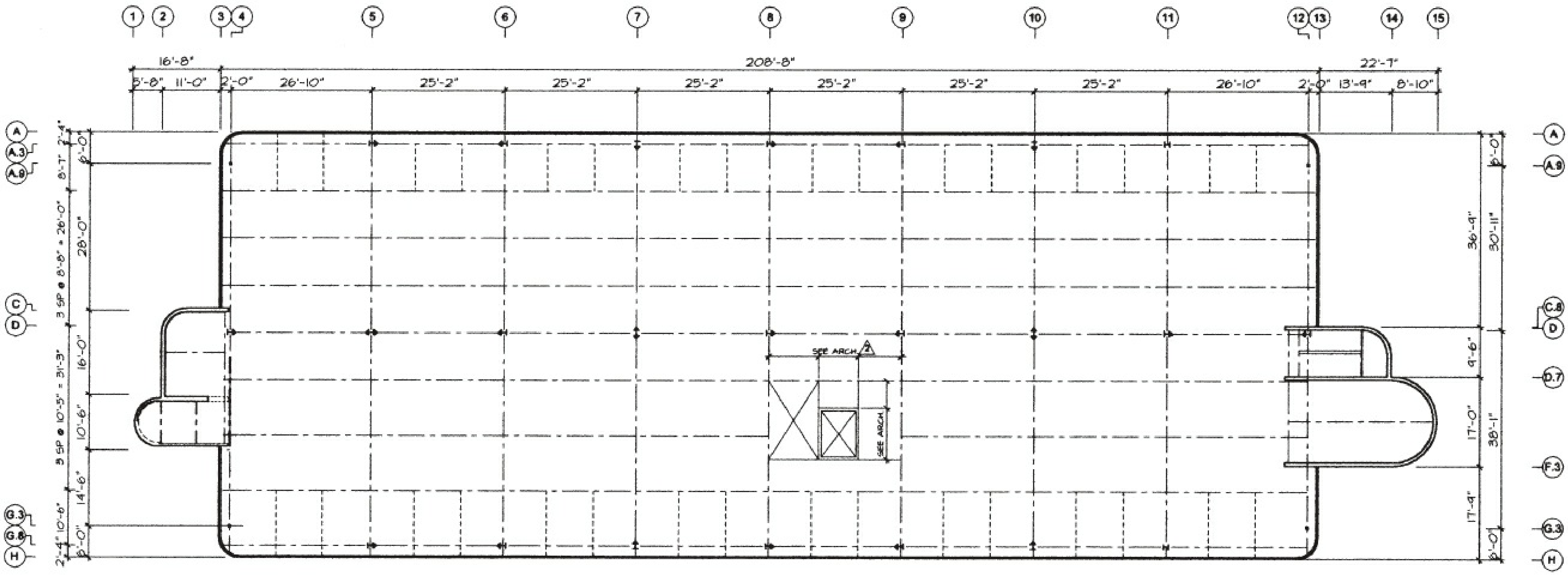


Third Floor Framing Plan

Figure 9.116 Madison Building—Stage III: Working drawing—third…floor framing plan.

Stage IV

On the Stage IV drawing, all the necessary dimension lines and the numerical values are shown. These numerical values have been carefully checked with the dimensional values found in Figure 9.117 of the third…floor plan. Checking the dimensional values is critical to maintaining the structural simplicity of the steel frames. Notes referencing the architectural drawings and details in the elevator area are indicated. The fourth stage of this plan is shown in Figure 9.117.

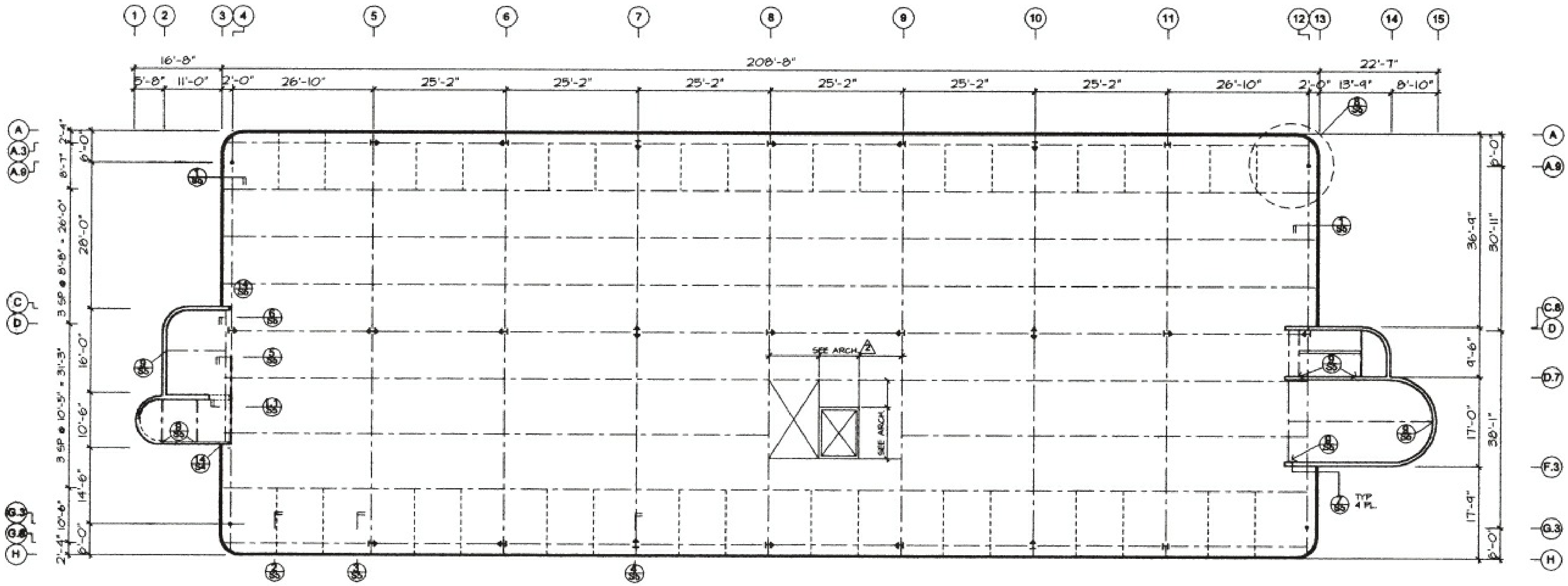


Third Floor Framing Plan

Figure 9.117 Madison Building—Stage IV: Working drawing—third…floor framing plan.

Stage V

The main difference between the drawing in Stage IV and Stage V is the addition of the various structural detail bubbles and their symbols showing an enlarged drawing for a particular structural area. The numerous structural details that are designated by the detail bubbles are usually drawn and shown as part of the structural engineer's plans. The drawing for Stage V is depicted in Figure 9.118.



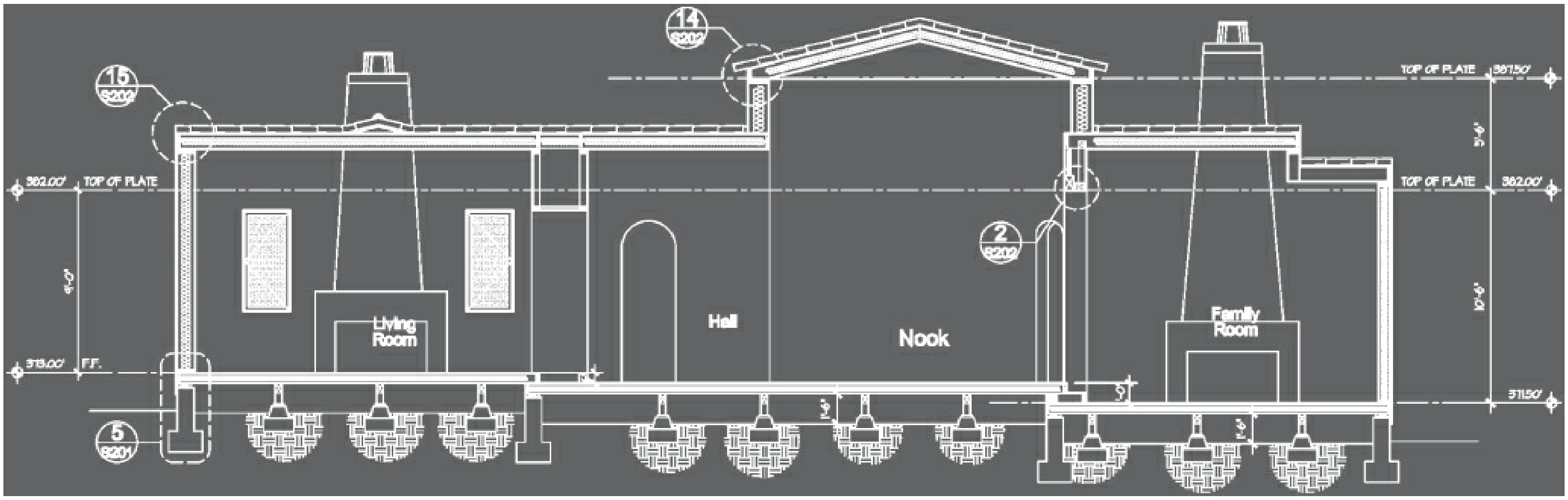
Third Floor Framing Plan

Figure 9.118 Madison Building—Stage V: Working drawing—third…floor framing plan.

Key Terms

- axial reference locations
- backhoe
- beam and column elevation heights
- brick pavers
- call…outs
- concrete caisson
- concrete pads
- convection
- crosshatch
- footing design
- foundation footing details
- grade beam
- hidden line
- hip rafters
- legend
- pedestal
- pilasters
- post hold…down
- shot…ins
- two…pour system

Chapter 10
BUILDING SECTIONS



BUILDING SECTIONS DEFINED

A **building section** cuts a vertical slice through a structure in much the same way a floor plan is a horizontal slice through the building. For the computer, a section is a cut along the *z*–*x* axis or the *z*–*y* axis. It is also an integral part of the dimensional reference system described earlier in this book. Figure 10.1 shows a vertical slice cut through a wood…framed, two…story residence. To further examine the various roof, floor, and wall conditions found at the location of that particular slice, we can enlarge the elements and then call it a **detail**, as seen in Figure 10.2.

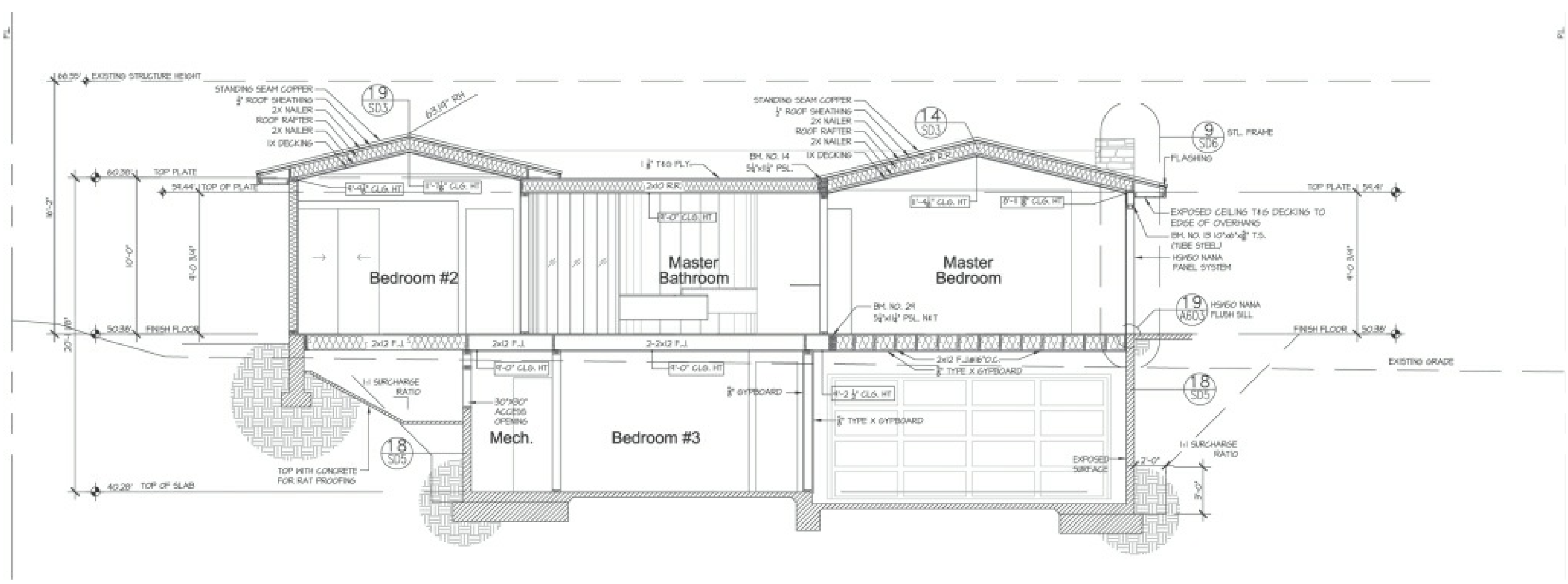
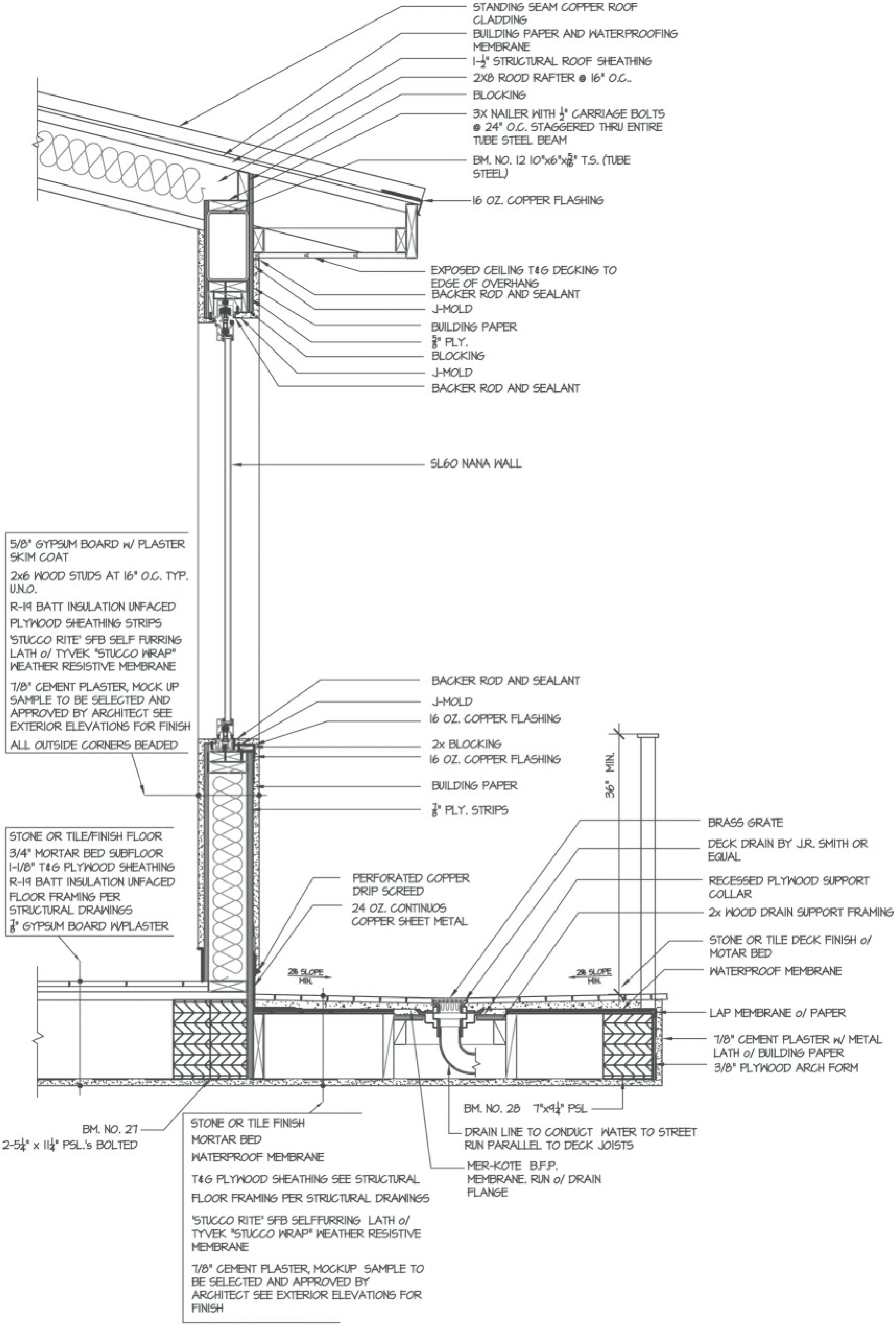


Figure 10.1 Vertical slice through a building.

(Courtesy of the Bailey residence.)



Wall Section thru Master Bedroom

SCALE: 1"=1'-0"

Figure 10.2 Portion of a section.

(Courtesy of the Bailey residence.)

The building section is second only to the floor plan in importance, because it reveals how the building is assembled, describes the collective parts of the building, and demonstrates the volume of each specific building area. The building section allows the discovery of essential details. In many instances, for example, the building section reveals potential problems in the intersection of walls, floors, stairs, ceilings, and roof.

To draw a building section, select a cross…section location with relevant architectural and structural information. When given the task of drawing a building section, you first need to gather basic information, including:

1. Type of foundation
2. Floor system
3. Exterior and interior wall construction
4. Beam and column sizes and their material
5. Plate or wall heights
6. Floor elevations
7. Floor members, size, and spacing
8. Floor sheathing, material, and size
9. Ceiling members, size, and spacing
10. Roof pitch
11. Roof sheathing, material, and size
12. Insulation requirements
13. Finished roof material
14. Ceiling heights

Although it may not be possible to gather all of this data early in the design stage, it is possible to construct the parts that are known and add data as the information comes in. When you have gathered this information, select a suitable architectural scale. Usually, the scale ranges from 1/8″ = 1′…0″ to ¼″ = 1′…0″. The scale depends on the size and complexity of the project and should be chosen to maintain clarity. Most commercial jobs use 1/8″, and most residential jobs ¼″.

As you draw the building section, visualize the erection sequence for the structure and the construction techniques for the material(s) being used. See Figure 10.3.

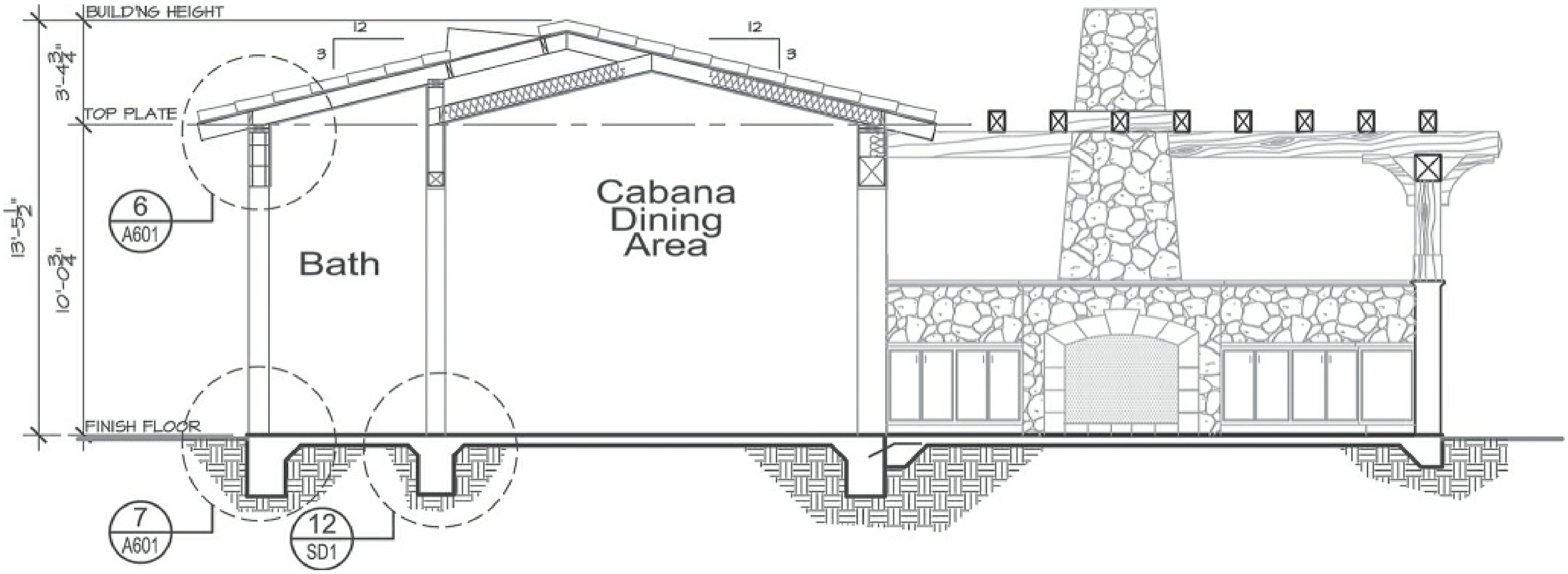


Figure 10.3 Building section.

(Courtesy of Mr. & Mrs. Thompson.)

The first step is to show the concrete floor and foundation members at that particular location. Although foundation details should be drawn accurately, they need not be dimensioned or elaborated upon; all the necessary information will be called out in the larger‐scale drawings of the individual foundation details.

Next, establish a **plate height**. (A **plate** is a horizontal timber that joins the tops of studs.) Here the plate height is noted, measuring from the top of the concrete floor to the top of the two plates (2–2 × 6 continuous) of the wood stud wall. This height also establishes the height to the bottom of the floor joist for the second‐floor level. Once the floor joists are drawn in at the proper scale, repeat the same procedure to establish the wall height that will support the ceiling and roof framing members. The height is typically selected based on the desire of the client, the building height constraints or budget. There is a current trend where the plate heights have increased from standard residential heights of around 8′ to 9′ or even 10′. Commercial buildings can vary but are between 12′ and 15′ high to allow for mechanical chases and equipment to be located above the drop ceiling line.

As indicated, the roof pitch for this particular project is a ratio of 3 to 12; the roof rises 3 inches for each 12 inches of horizontal measurement (the roof rises 3 feet for every 12 feet). You can draw this slope or angle with an architectural scale, or you can convert the ratio to an angle degree. Draw the roof at the other side of the building in the same way, with the intersection of the two roof planes establishing the ridge location. Mission clay tile was chosen for the finished roof material for this project.

When you have drawn in all the remaining components, such as stairs and floor framing elevation changes, note all the members, roof pitch, material information, and dimensions. See Figure 10.4.

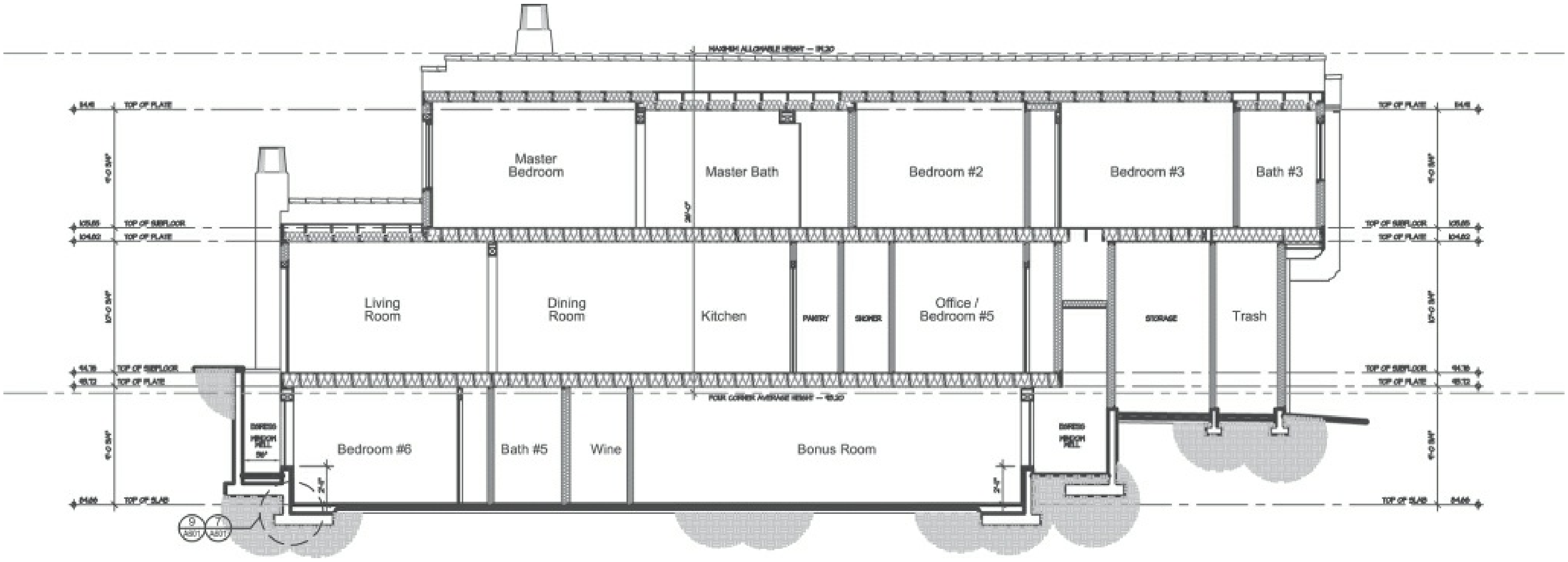


Figure 10.4 Building section.

(Courtesy of Mr. & Mrs. Givens.)

Figure 10.5 shows various reference symbols. These symbols refer to an enlarged drawing of those particular assemblies. To demonstrate the importance of providing enlarged details, Figure 10.5 shows a building section of a wood‐framed structure with critical bolted connections. A reference symbol (the number 1 over the number 8, in a reference bubble) is located at the roof framing and wall connection. This connection is made clear with an enlarged detail, showing the exact location and size of bolts needed to satisfy the engineering requirements for that assembly. See Figure 10.6.

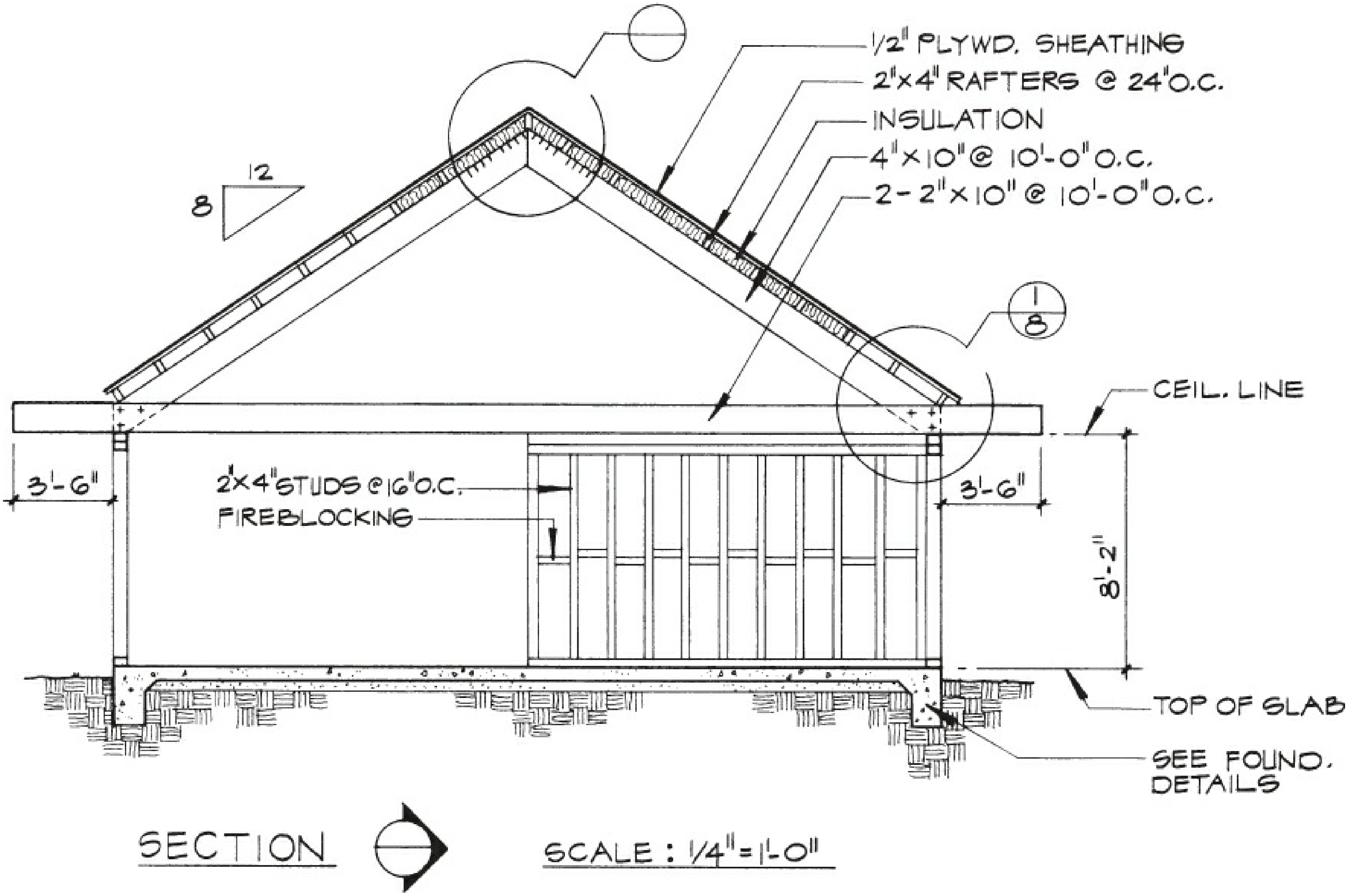


Figure 10.5 Structural section.

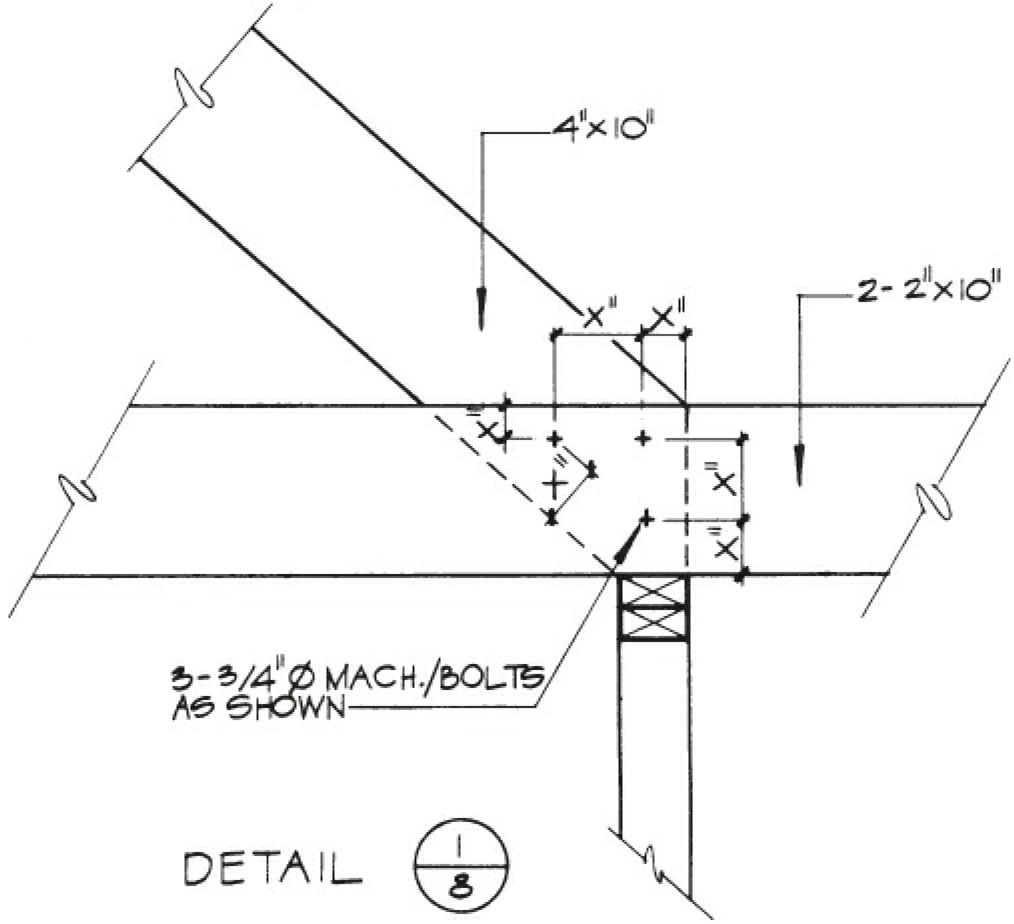


Figure 10.6 Bolted connection.

In BIM or a three‐dimensional model, the building section can be sliced or sectioned or flattened. The various construction members, such as the studs and rafters, can then be rotated in a three‐dimensional model to reveal and explain the construction features that are not readily obvious in a two‐dimensional drawing.

Number and Place of Sections

Draw as many building sections as you need to convey the necessary information, with the greatest possible clarity, to the contractors building the structure. The building department typically requires a minimum of two sections, one cross‐section and one longitudinal section often one must cut through the stairs.

Building sections are used to investigate various conditions that prevail in a structure. These sections can point out flaws in the building's structural integrity, and this information can lead to modifications in the initial design.

The number of building sections required varies according to the structural complexity of the particular building. For a simple rectangular building, you may need only two building sections to clearly provide all the required information. However, for a building with a more complex shape, you may require five or more sections to provide all the structural and architectural information. See Figure 10.7.

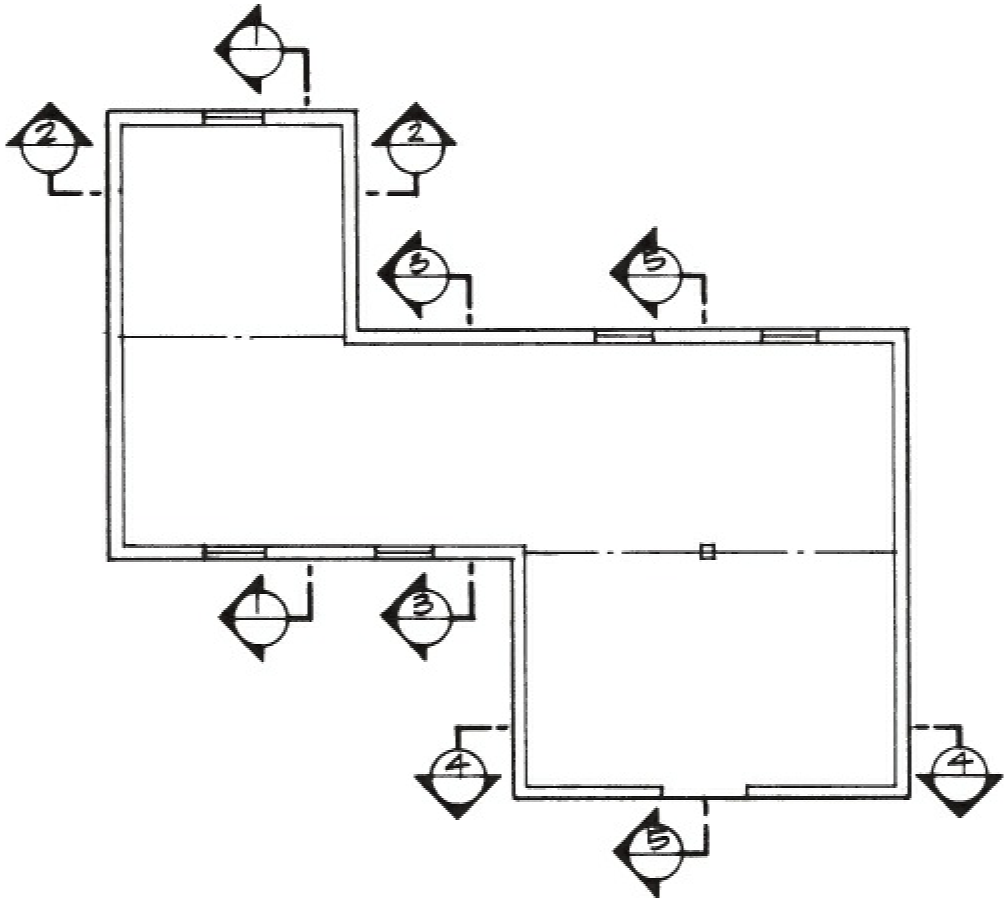


Figure 10.7 Building section locations of interest.

DRAFTING A BUILDING SECTION

After deciding where a section is to be taken so as to reveal the greatest amount of information, a grid pattern is drafted. The horizontal lines of the grid represent the floor line and the plate line (at the top of the two top plates). All of the vertical lines represent the walls of the structure or column locations. See Figure 10.8.

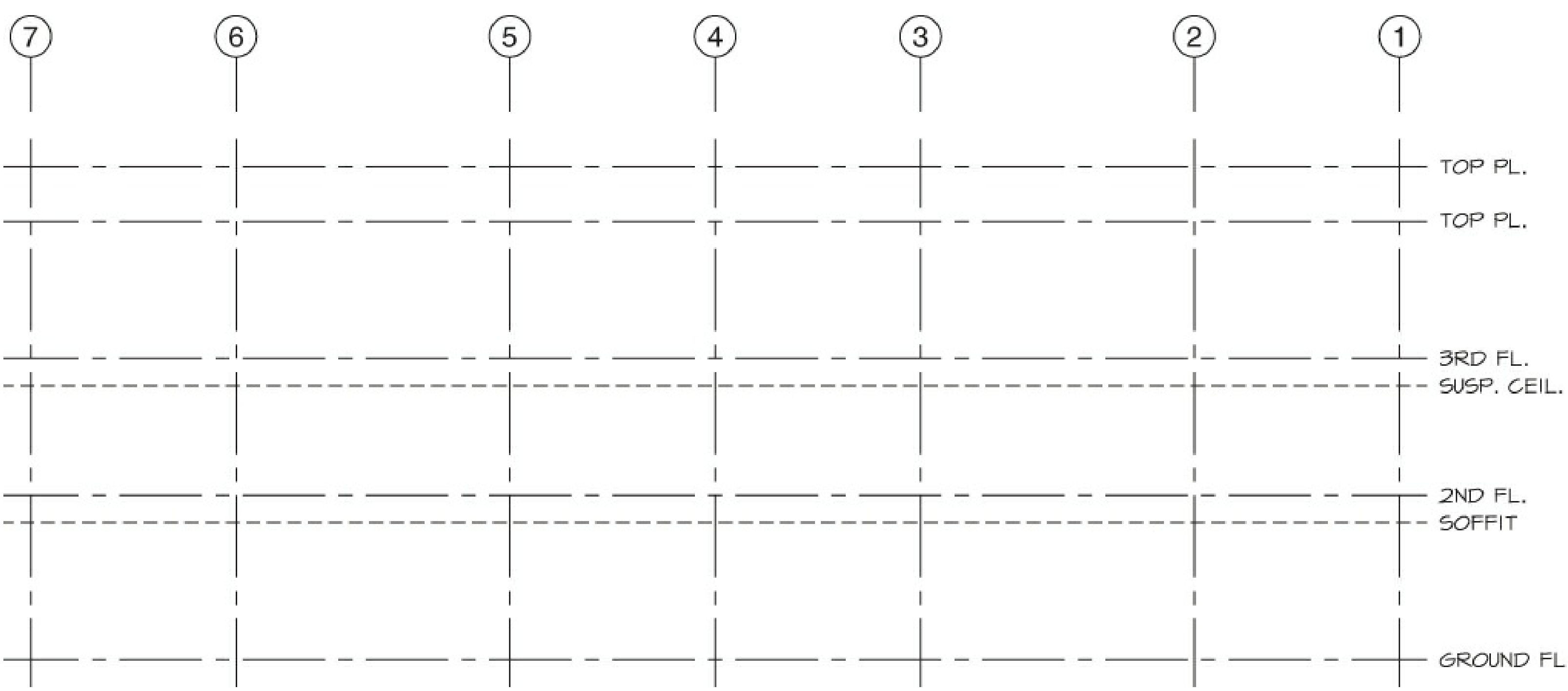


Figure 10.8 Layout of the grid pattern.

A scale of ¼″ = 1′–0″ is ideal, but because of the size of the structure or the limits of the sheet, a scale of 1/8” = 1′ –0″ might be used.

Before you decide on a smaller scale, explore the possibility of removing redundant portions of the building by virtue of break lines. See Figure 10.10. If the building is symmetrical, a partial section, as shown in Figure 10.18, may suffice.

If the building section is to be drawn at the same scale as the floor plan, the drafter need only transfer measurements by projecting or extending lines down from the floor plan to section. If the building section is drafted at twice the size of the floor plan, you can simply transfer the measurements and double the scale.

With the computer, you do not have a problem with scale because the floor plan and the building section, along with the entire set of construction documents, are drawn at full scale in model space. Only when you import the drawings into paper space do you need to add a scaling factor.

If the floor plan was drawn in paper space at a scale of ¼″ = 1′–0″ rather than at full scale in model space, you can quickly change the scaling factor, using the computer, from the ¼″ plan to another scale.

Pitch

If a pitch (an angle) is involved and it is constant, an adjustable triangle is handy. Another option is to actually measure the pitch. If you have a template, look for a pitch scale printed on its side. If you are in the market for a plan template, check the various brands carefully because there are templates that will measure pitch; have markings for typical heights of equipment from the floor; and even plot spacing, such as for 4″ and 6″ tile, 16″ spacing for stud and joist position, and door swings, among other items.

If you understand the process of drafting a building section, you might develop a shortcut method. For example, if you have access to a plain–paper copier that enlarges and reduces, it would be a simple matter to reproduce an eave detail to the proper scale. Then, with the same pitch on a sheet, place it under the building section and trace.

TYPES OF BUILDING SECTIONS

Because the design and complexity of buildings vary, types of sections also vary. The type of section that will best demonstrate the required data is the determining factor in choosing the required types of sections.

Wall Sections

Simple structural conditions may only require wall sections to convey the necessary building information. Structural sections for a small industrial building, for example,

might use wall sections.

In most cases, wall sections can be drawn at larger scales, such as ½″ = 1′…0″. These larger…scale drawings allow you to clearly elaborate building connections and call…outs without having to draw separate enlarged details.

Figures 10.9 through 10.12 are for an industrial building and show how wall sections are incorporated into a set of construction documents. Figure 10.9 shows the floor plan with two main exterior and one interior bearing wall conditions. These wall conditions are referenced to wall sections and are shown in Figures 10.10.

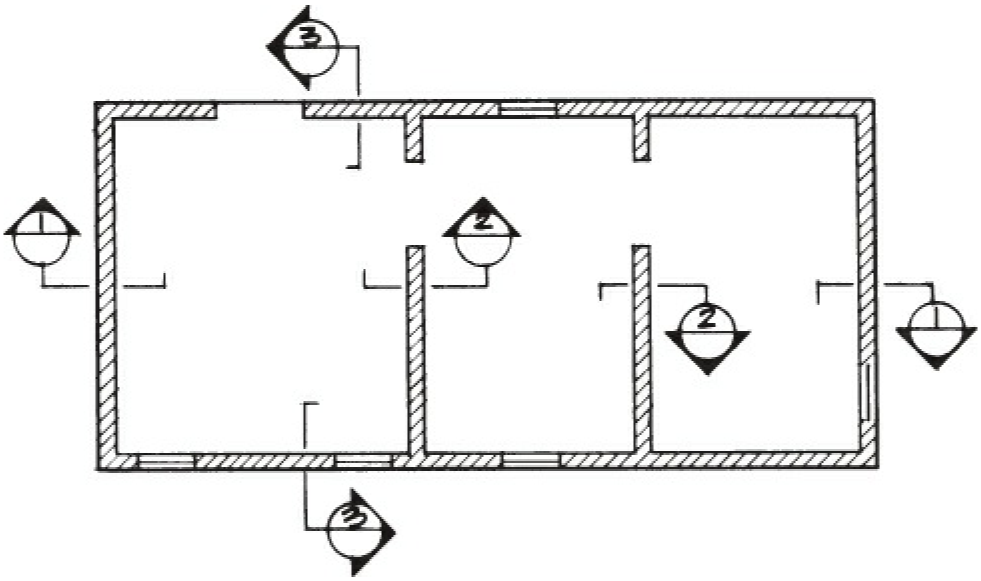


Figure 10.9 Floor plan of an industrial building.

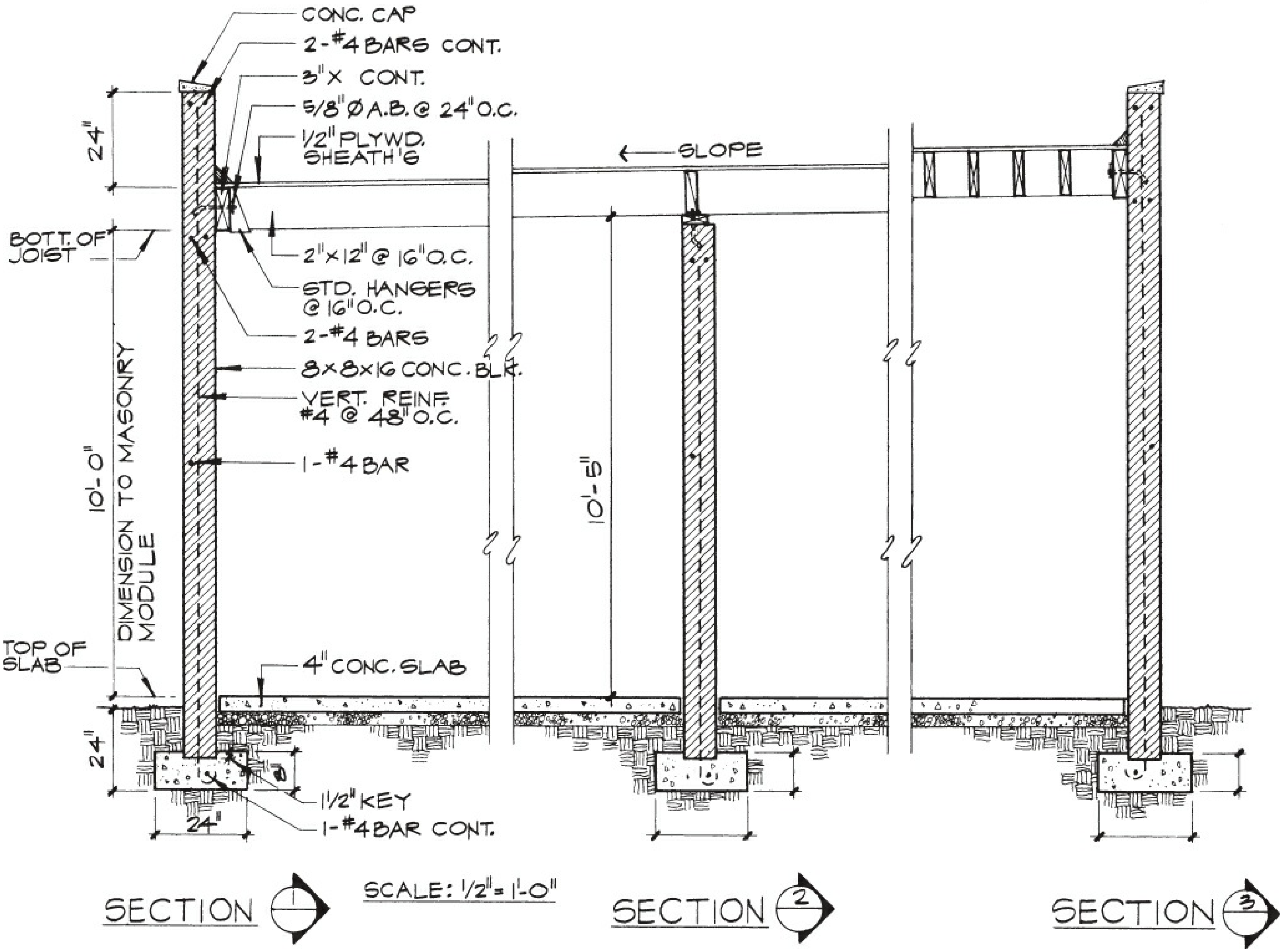


Figure 10.10 Exterior wall section.

Figure 10.11 Interior wall section.

Figure 10.12 Exterior wall section.

When drawing at a large scale, you can note all the footing information directly on the wall section, thereby making separate foundation details unnecessary. Next, draw the masonry wall using 8 × 8 × 16 concrete block as the wall material. Because a modular unit is being used for the wall construction, a wall height is established that satisfies the 8″ concrete‐block increments. Draw the roof‐to‐wall assembly at the desired height above the concrete floor, with the various framing connections and members needed to satisfy the structural requirements. After you finish the drawing, add notes for all members, steel reinforcing, bolts, and so forth. Other wall sections, as shown in Figures 10.10 and 10.10, are drawn and noted similarly. Note that while Figure 10.10 is similar to Figure 10.10, different roof framing conditions exist.

In short, large‐scale wall sections allow the structural components and call‐outs to be clearly drawn and usually make larger‐scale details, such as framing connections and foundation details, unnecessary.

Full Sections

For projects with complex structural conditions, you should draw an entire section. This gives you a better idea of the structural conditions in that portion of the building, which can then be analyzed, engineered, and clearly detailed.

Figure 10.13 shows a building section through a residence that has complex framing. Here, you can clearly understand the need for a full section to see the existing conditions. When doing a full section, you should draw this type of section in a smaller architectural scale, ¼″ = 1′…0″. Again, when you use a smaller scale for drawing sections, you must provide enlarged details of all relevant connections. The circled and referenced conditions in Figure 10.13, for example, will be detailed at a large scale.

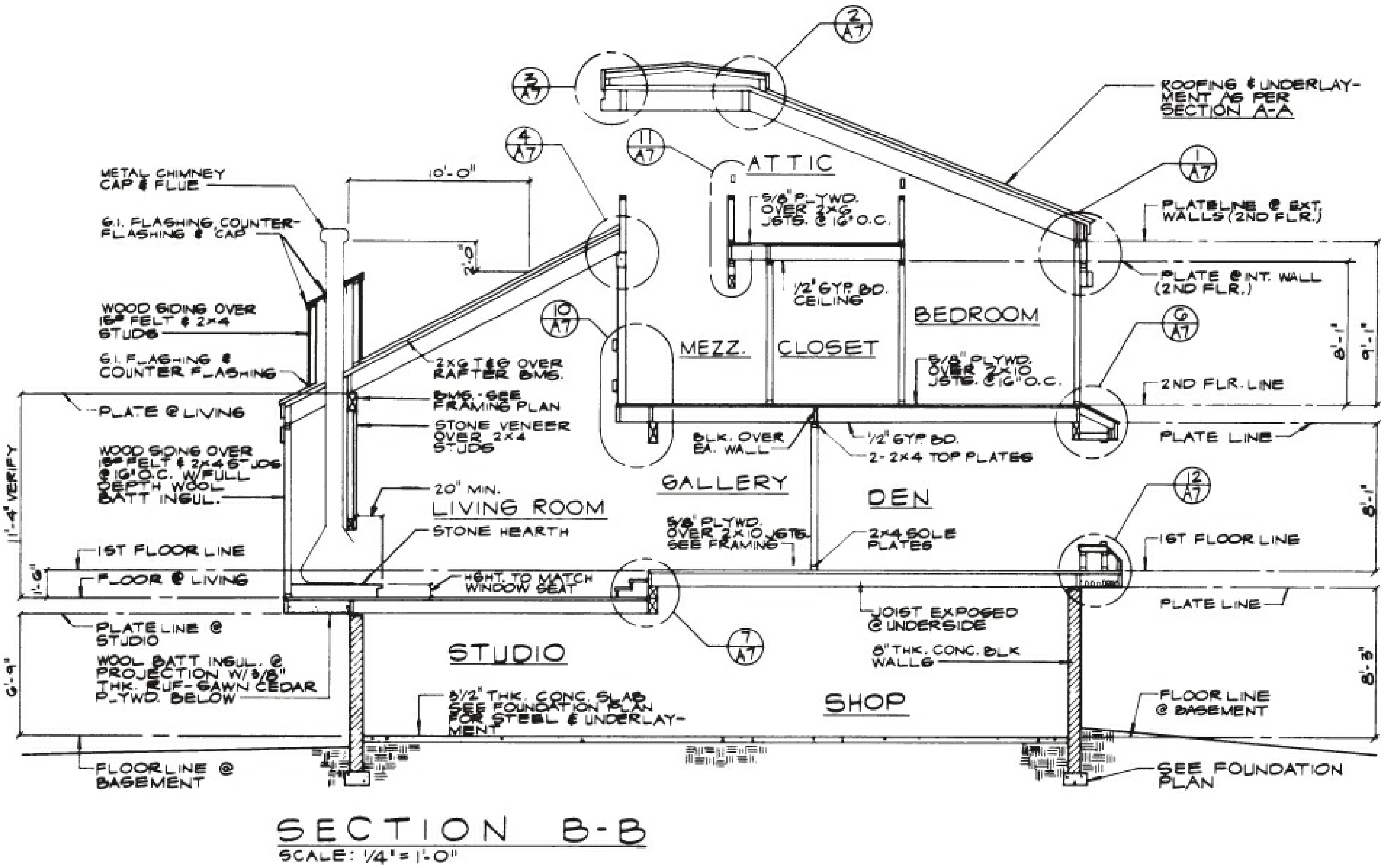


Figure 10.13 Full section.

(Courtesy of Steve L. Martin.)

Whether in the area of schematic design or design development, a design section can be created to aid in the design process. A design section utilizes no structural detail; in fact, it is a drawing that describes volume within a building and graphically holds space for the future structure. See Figures 10.14 and 10.15.

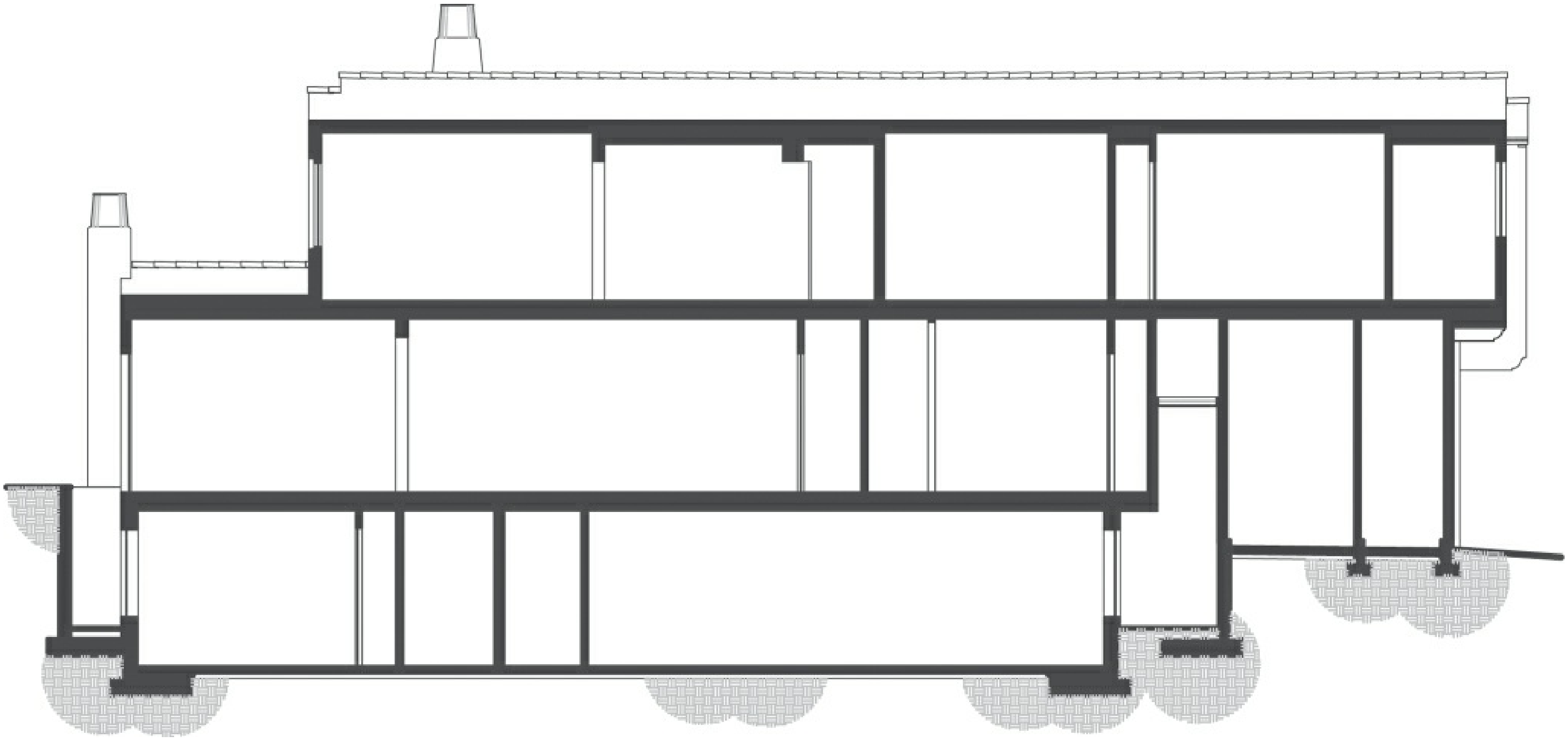


Figure 10.14 Building design section.

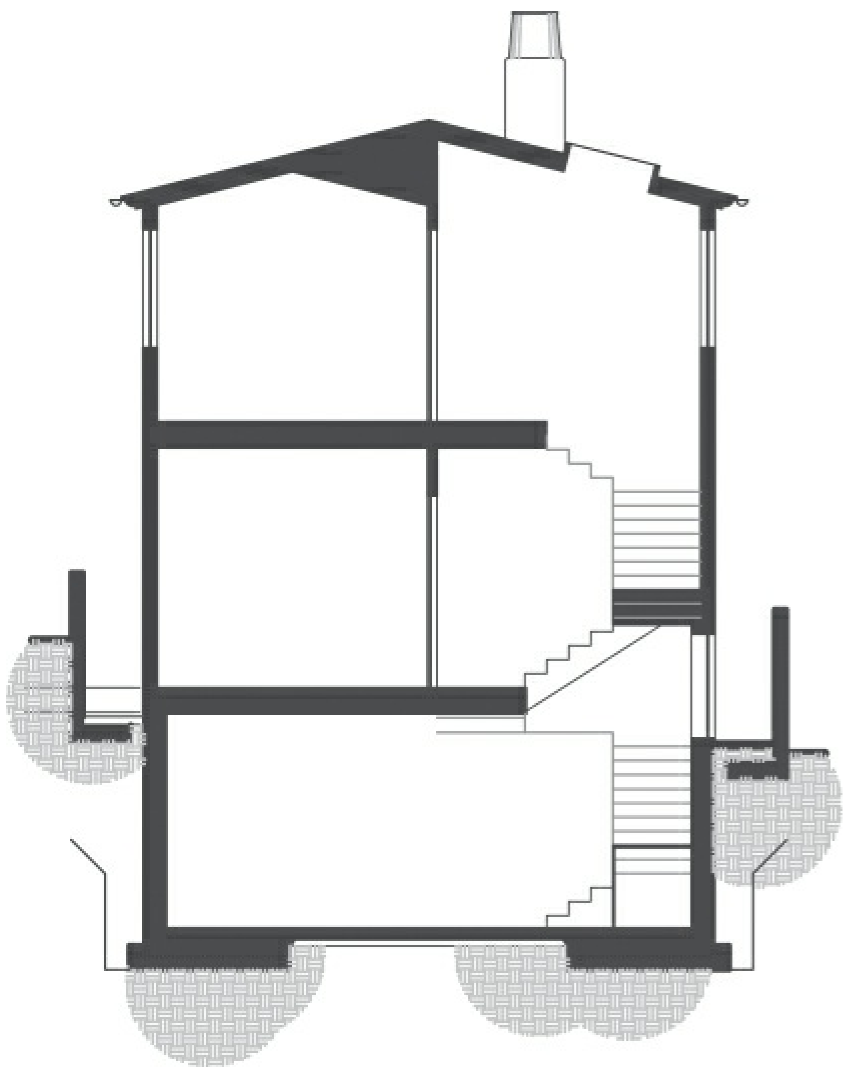


Figure 10.15 Building design section.

Notice the level of interior detail in Figures 10.16 and 10.17. The option of providing

interior detail within the section allows the client to better understand the relationship of the elements inside the room. In this regard, a design section also serves another important purpose: it is one of the few drawings that explain the volume of the rooms. This is also helpful to the consultants, such as mechanical, electrical, and structural engineers. With this kind of section, the mechanical engineers can best determine the space allotted for them to work in, the electrical engineers can determine which types of fixtures will best light the room, and structural engineers can shape the structure to achieve the shape concept designed by the architect.

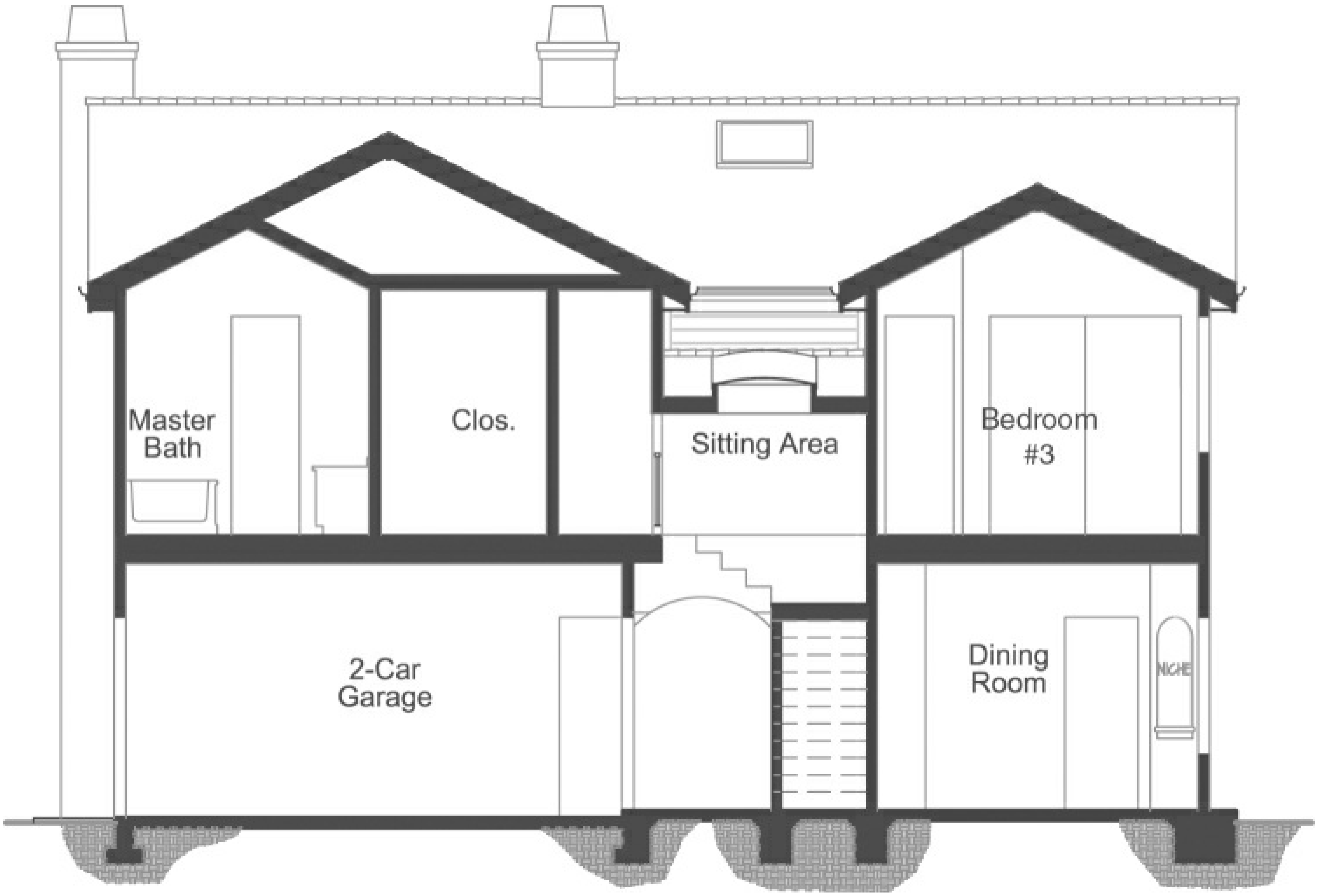


Figure 10.16 Building design section.

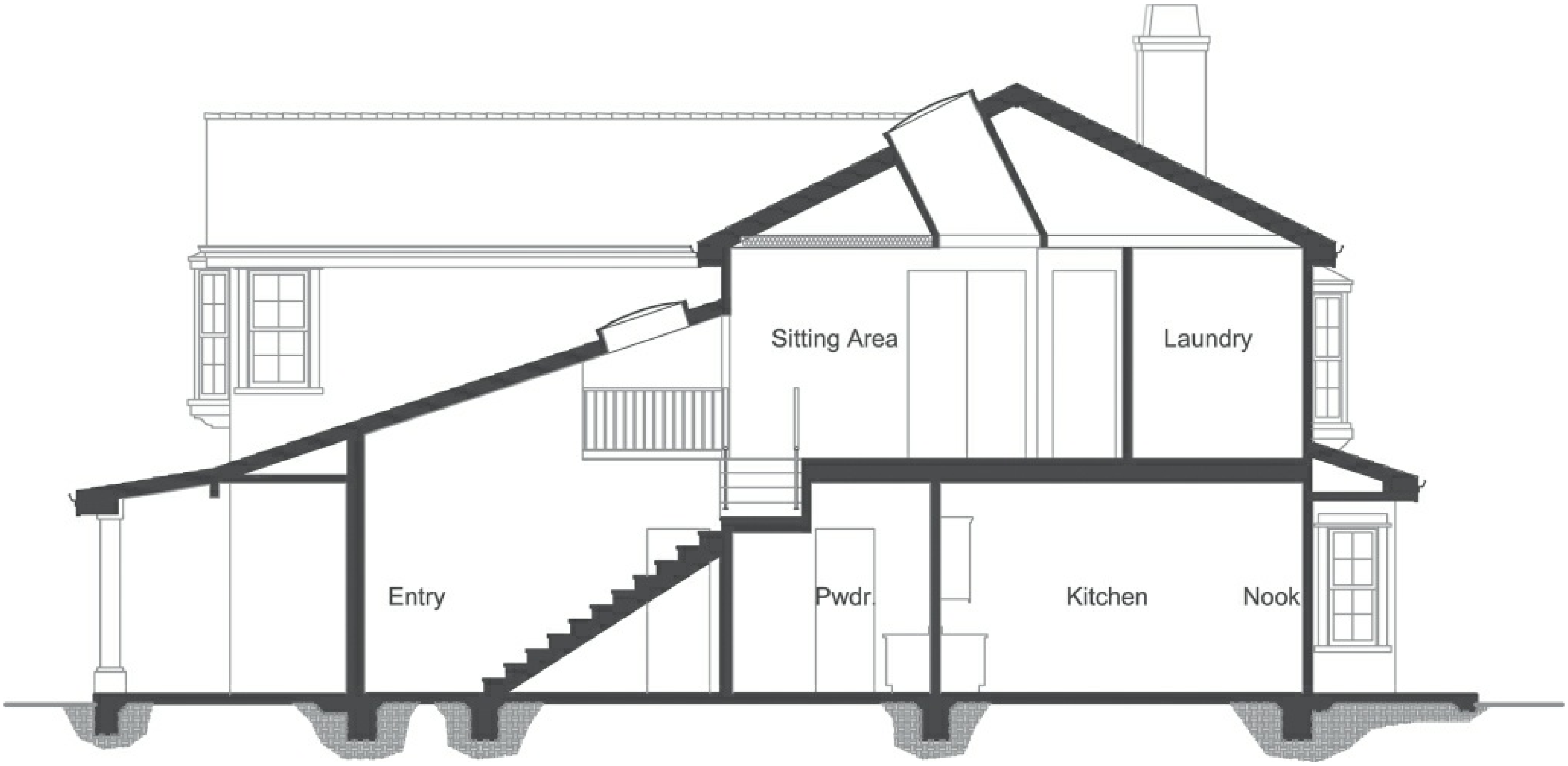


Figure 10.17 Building design section.

Partial Sections

Many projects have only isolated areas that are structurally complex. These areas are drawn in the same way as a cross‐section, but they stop when the area of concern has been clearly drawn. This results in a partial section of a structural portion.

In addition to the structural aspect of sections, the designed shape of the building is exposed to better demonstrate the 3‐D aspect of the space. The section is an aid in realizing the space, for both the builder and the client.

The partial section shown in Figure 10.18 illustrates the structural complexities existing in that portion. Additional detailing is required to make other assemblies clear.

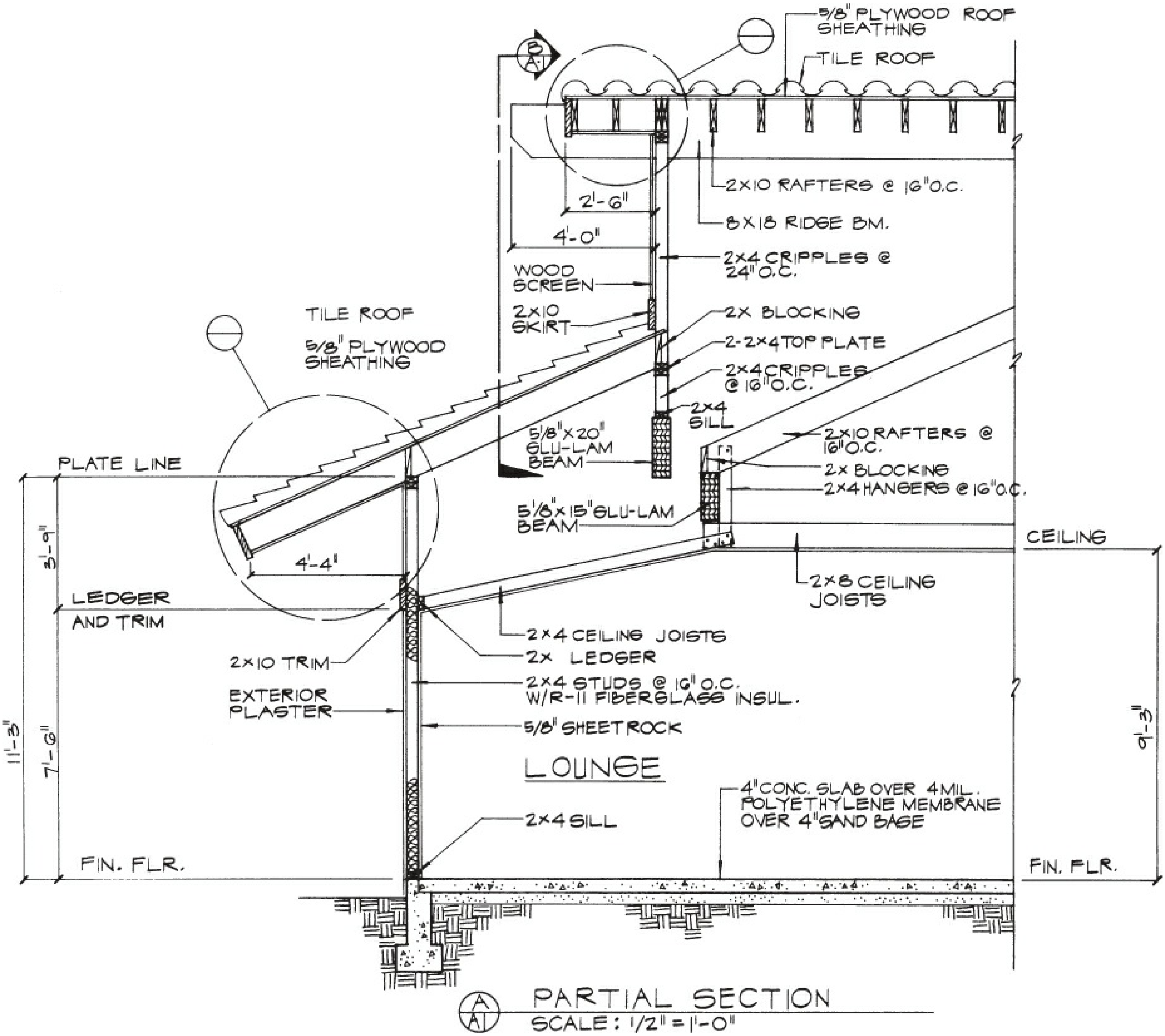


Figure 10.18 Partial section.

One of these assemblies, for example, may require a partial framing elevation to show a specific roof framing condition. This condition may be referenced by the use of two circles—each with direction arrows, reference letters, and numbers—attached to a broken line. Figure 10.19 shows this partial framing elevation, as referenced on Figure 10.18.

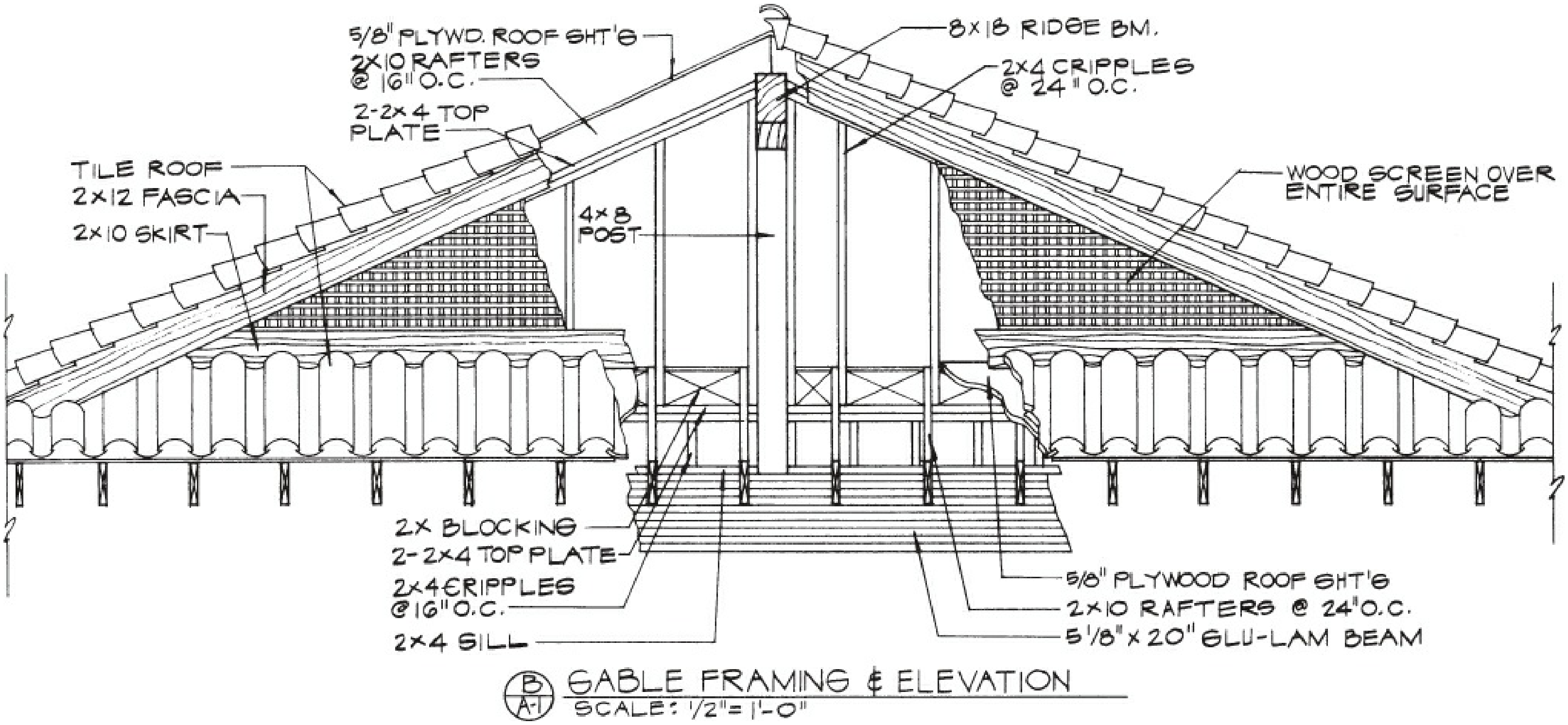


Figure 10.19 Framing elevation.

Steel Sections

For buildings built mainly with steel members, use elevations to establish column and beam heights. This approach coincides with the procedures and methods for the shop drawings provided by the steel fabricator. Both the architect and the structural engineer will review the shop drawings for intent and approve them prior to fabrication.

Figure 10.20 shows a structural section through a steel…framed building. In contrast to sections for wood…framed buildings, where vertical dimensions are used to establish plate heights, this type of section may establish column and beam heights using the top of the concrete slab as a beginning point. Each steel column in this section has an assigned number because the columns are identified by the use of an axial reference matrix on the framing plan, shown in Figure 10.21.

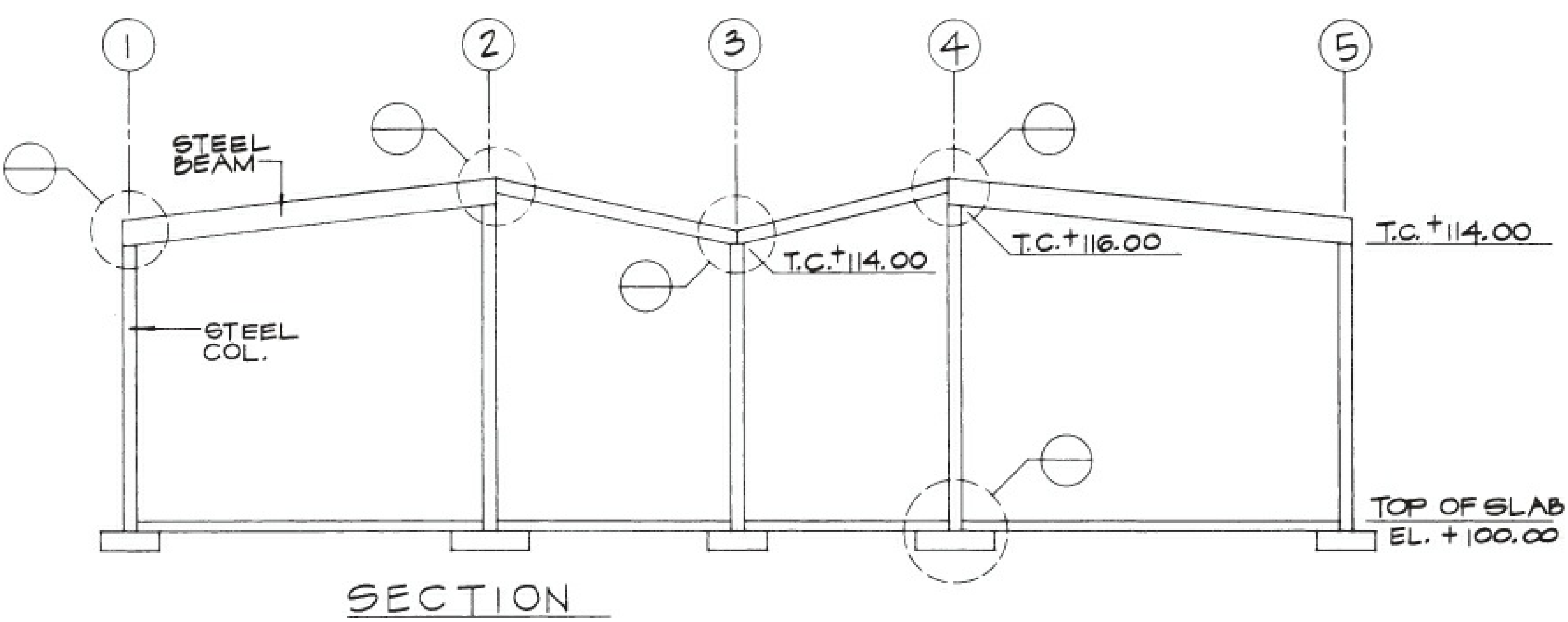


Figure 10.20 Steel frame section.

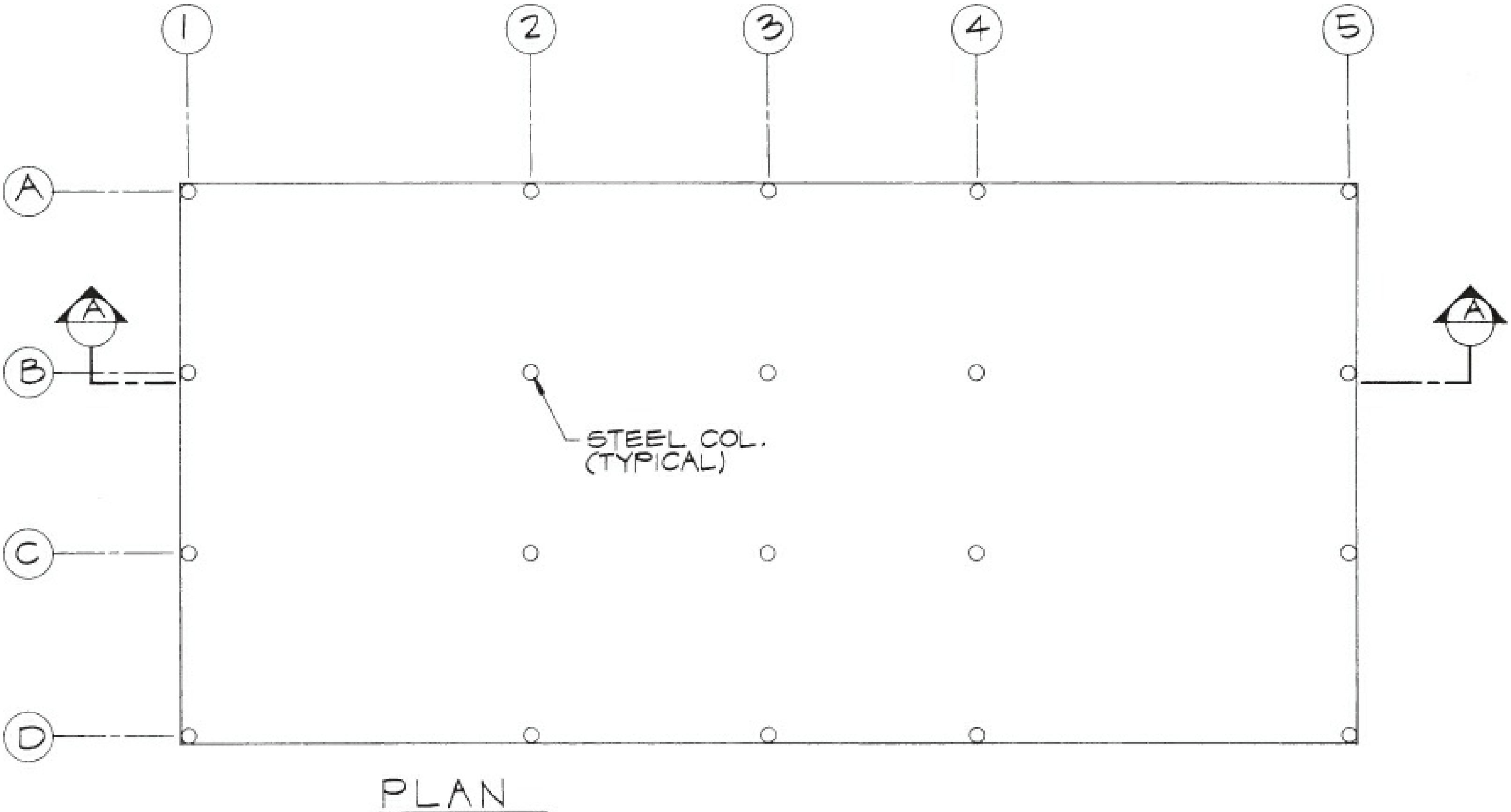


Figure 10.21 Column matrix.

Building Sections Checklist

1. Sections that clearly depict the structural conditions existing in the building
2. Sections referenced on plans and elevations
3. Dimensioning for the following (where applicable):
    a. Floor to top plate
    b. Floor to floor
    c. Floor to ceiling
    d. Floor to top of wall
    e. Floor to top of column or beam
    f. Cantilevers, overhangs, offsets, etc.
    g. Foundation details
4. Elevations for top of floor, top of columns and beams
5. Call…out information for all members, such as:
    a. Size, material, and shape of member
    b. Spacing of members

6. Call…out information for all assemblies, including fire assembly rating (if enlarged details are not provided)
7. Column and beam matrix identification, if incorporated in the structural plan
8. Call…out for subfloor, insulation location and size, and sheathing assembly
9. Roof pitches and indication of all slopes
10. Reference symbols for all details and assemblies that are enlarged for clarity
11. Designation of material for protection of finish for roof, ceiling, wall, and structural members
12. Structural notes applicable to each particular section, such as:
    a. Nailing schedules
    b. Splice dimensions
    c. Structural notes
13. Structural sections corresponding accurately to foundation, floor, and framing plans
14. Scale and title of drawing section

Building Section Stages

In this study example, a simple one…story residence with multiple floor levels is demonstrated in the section. Note the various heights of the floors and the plate heights. These are established early in the process and are critical in the initial layout of the sections.

Stage I (Figure 10.22). This stage establishes heights. As the floor plan controls the width and depth of the residence, the building sections control the heights. The floor line and plate line are the most critical from a building perspective. The Jadyn residence has three floor lines because of the change of level that occurs at the bearing wall located in the center of the structure. Many planning departments require that the top of the ridge be dimensioned to make sure it does not obstruct views for neighbors.

[**Figure 10.22**]() Stage I: Building sections.

Stage II ([Figure 10.23]()). The outline of the roof and the positioning of the bearing walls are incorporated at this stage.

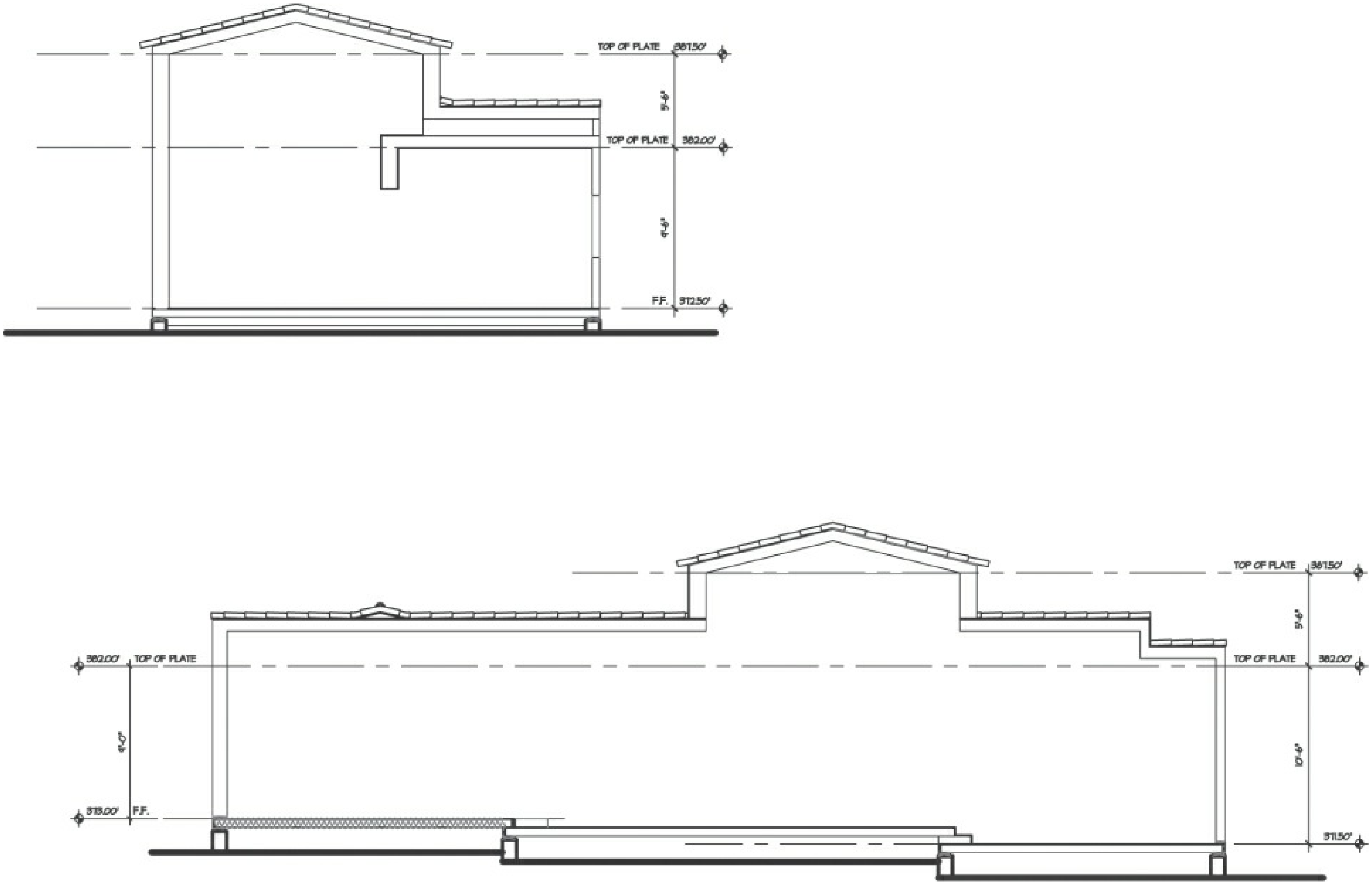


Figure 10.23 Stage II: Building sections.

Stage III (Figure 10.24). The building section is receiving detail at the various intersections such as the top and bottom plates, as well as the seat in the stem wall for the slab, are drafted.

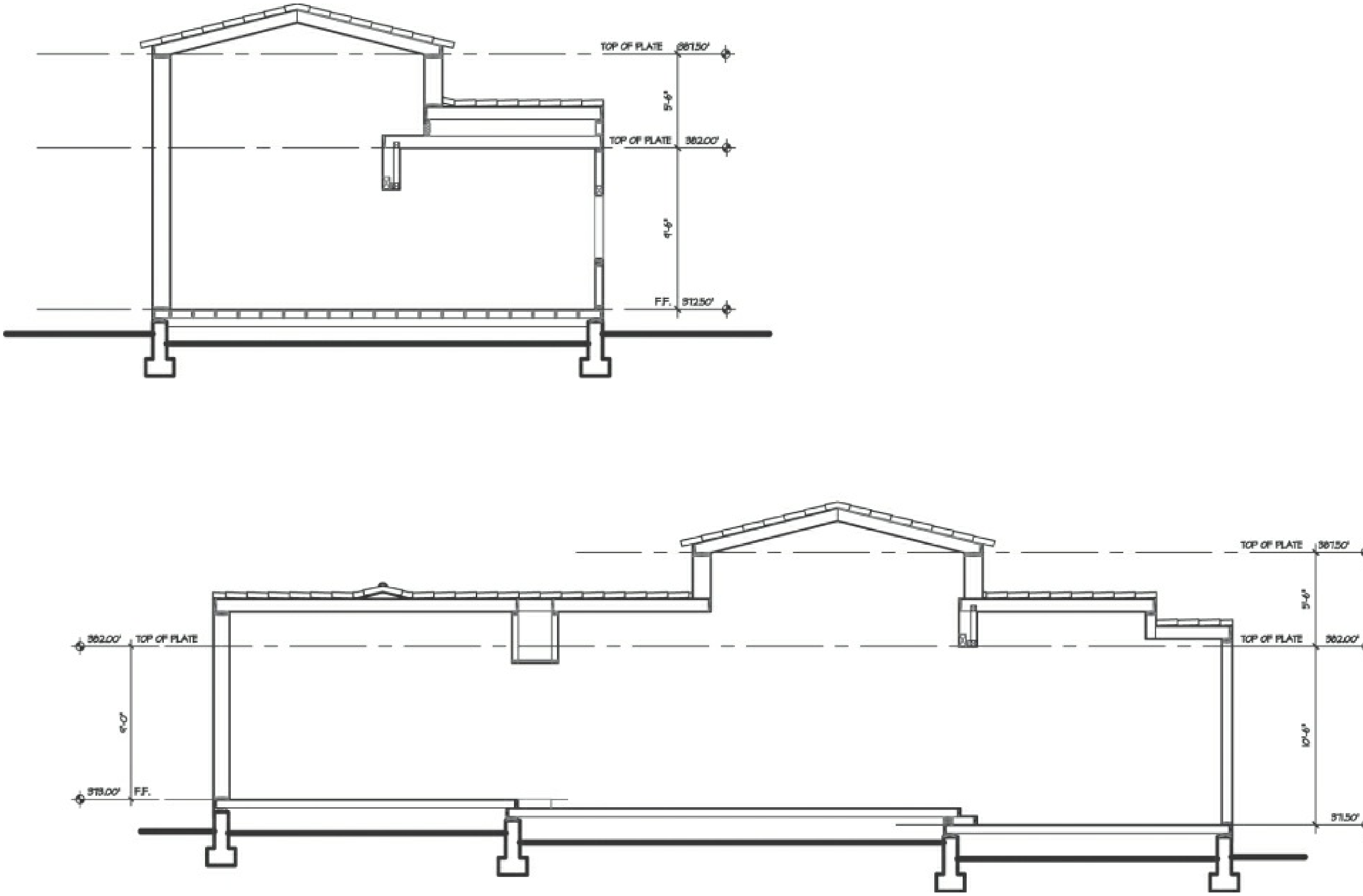


Figure 10.24 Stage III: Building sections.

Stage IV (Figure 10.25). This stage establishes all of the structural components, their position and direction, and even the direction in which the section was taken. Note the inclusion of the material designation and the makeup of the foundation with its insulation and sand. Walls show drywall, and the ceiling reveals the direction of the ceiling joist.

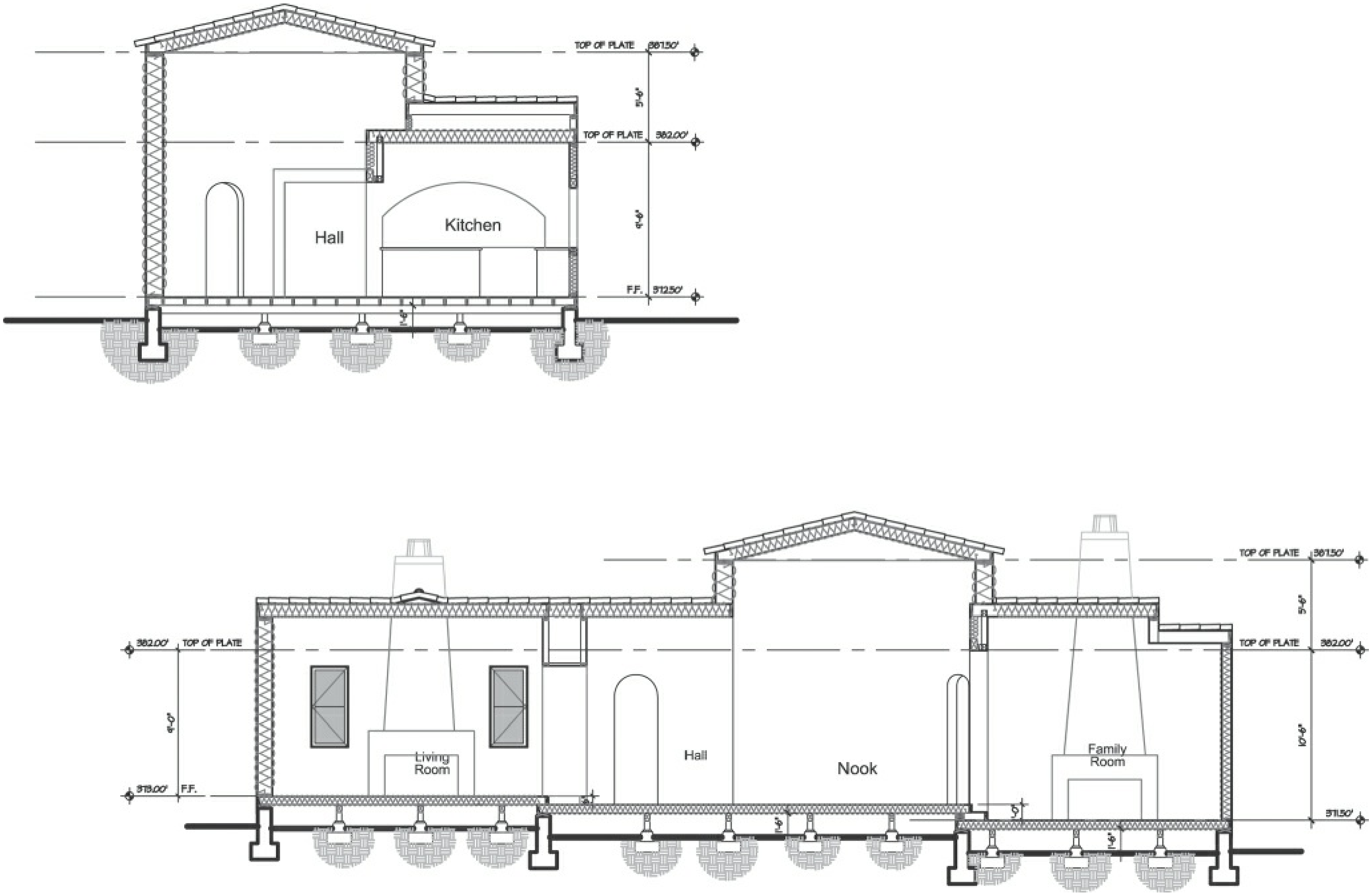


Figure 10.25 Stage IV: Building sections.

Stage V (Figure 10.26). Noting of the component parts and dimensioning become the most important tasks for this stage. All the parts should be identified. Material designations for insulation, roof material, and concrete are done at this stage, as well as referencing to reveal footing details and eave details.

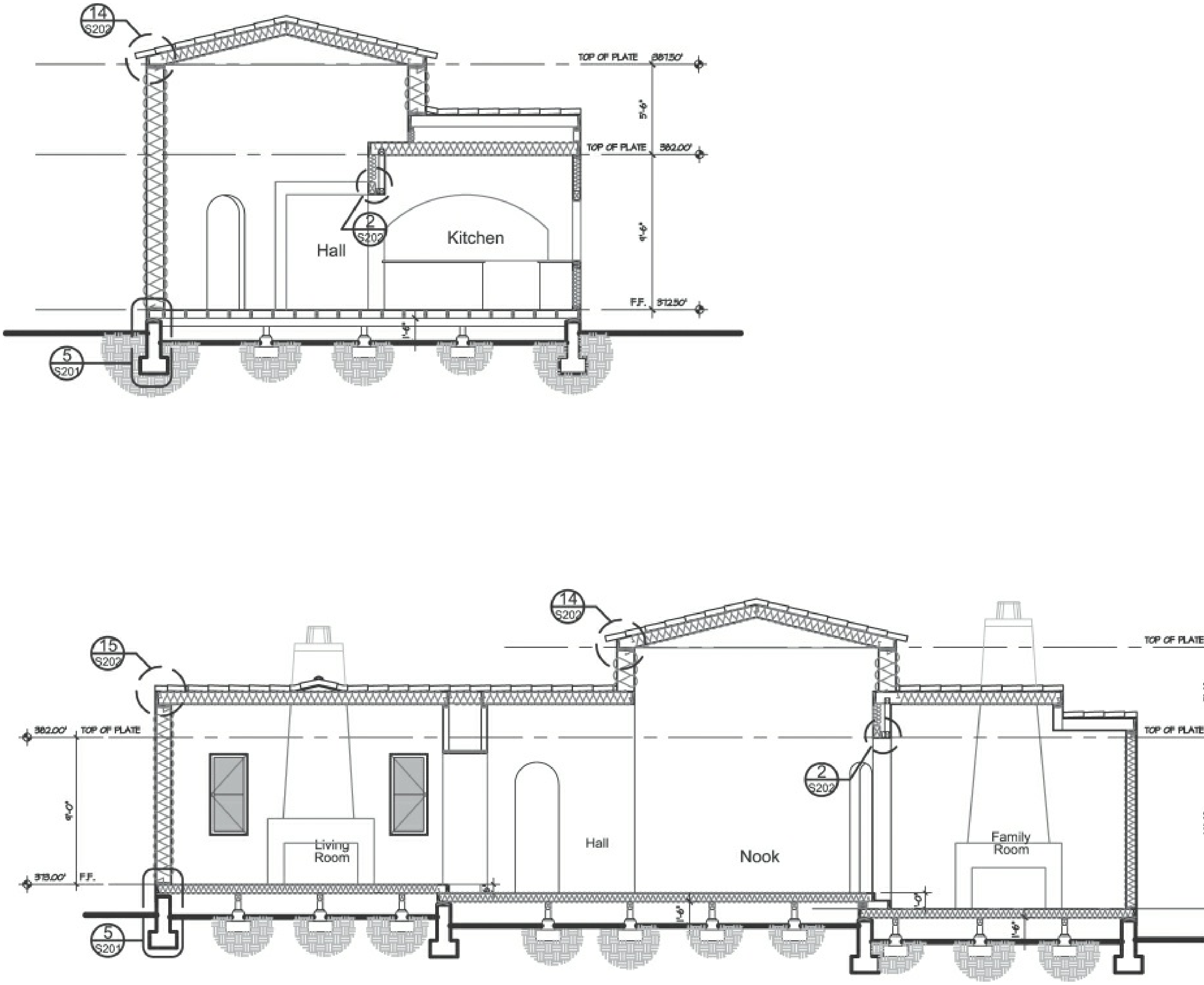
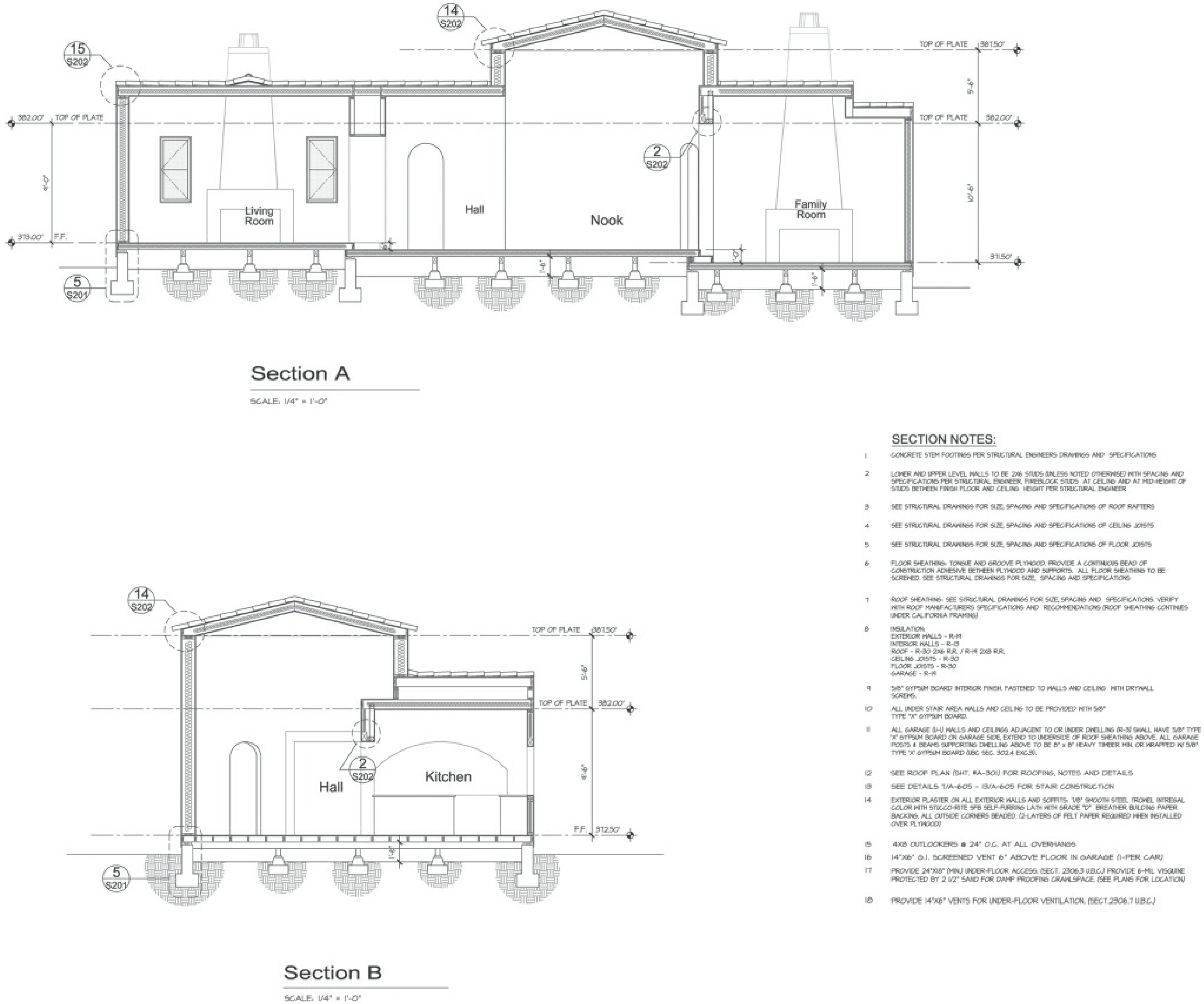


Figure 10.26 Stage V: Building sections.

Stage VI (Figure 10.27). The final stages of the details and the building section are merged at this point and positioned onto the title block sheet in the final plotting.



[Figure 10.27](#) Stage VI: Building sections.

In this study example, a more complex multistory residence is demonstrated in the cross… section. Note the various floors and the plate heights, which are ideally established early and are critical in the initial layout of the sections.

Stage I ([Figure 10.28](#)). If a flattened 3…D section is available, use this as the datum for future stages. All wall locations, plate heights, and level changes must be verified and corrected at this stage. If a flattened model is not available, the first stage of a 2…D drawing will establish the base or datum. Start by establishing the grade and its relationship with the floor line. Using this floor line as the main baseline, establish and measure the plate lines and floor lines of subsequent floors. In larger buildings, measurement may be in decimals. This is particularly true in steel structures, where the tips of the columns and tops of the floor girders are critical during installation.

Figure 10.28 Stage I: Establishing datum.

Stage II (Figure 10.29). The outline of the structure is now positioned, including the roof. On 3‒D drawings, the walls are already positioned, but in a 2‒D drawing the walls must be positioned by aligning the datum lines with a partial floor plan where the cut occurs (see Figure 10.30). In the schematic stage of design, a section may look very similar to the one in Figure 10.29.

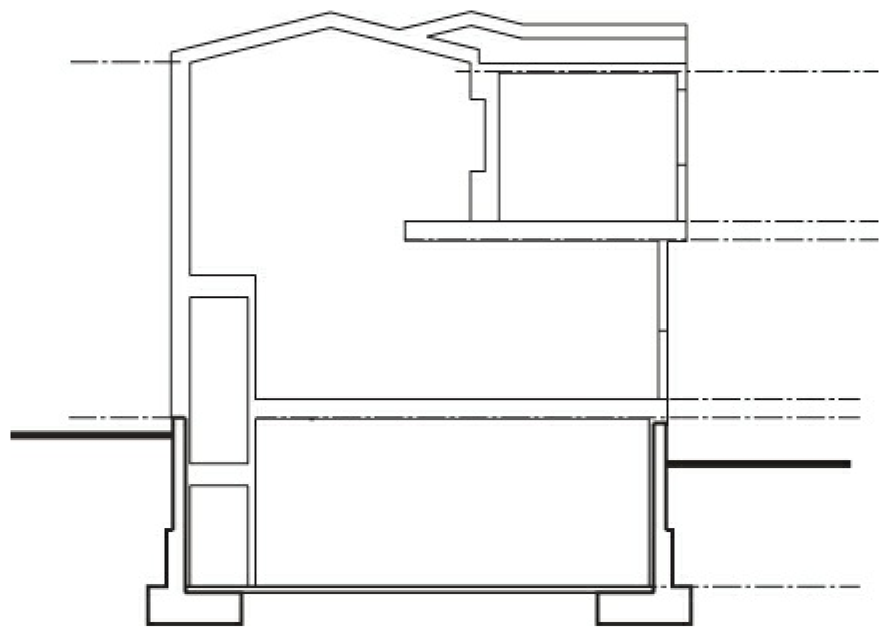
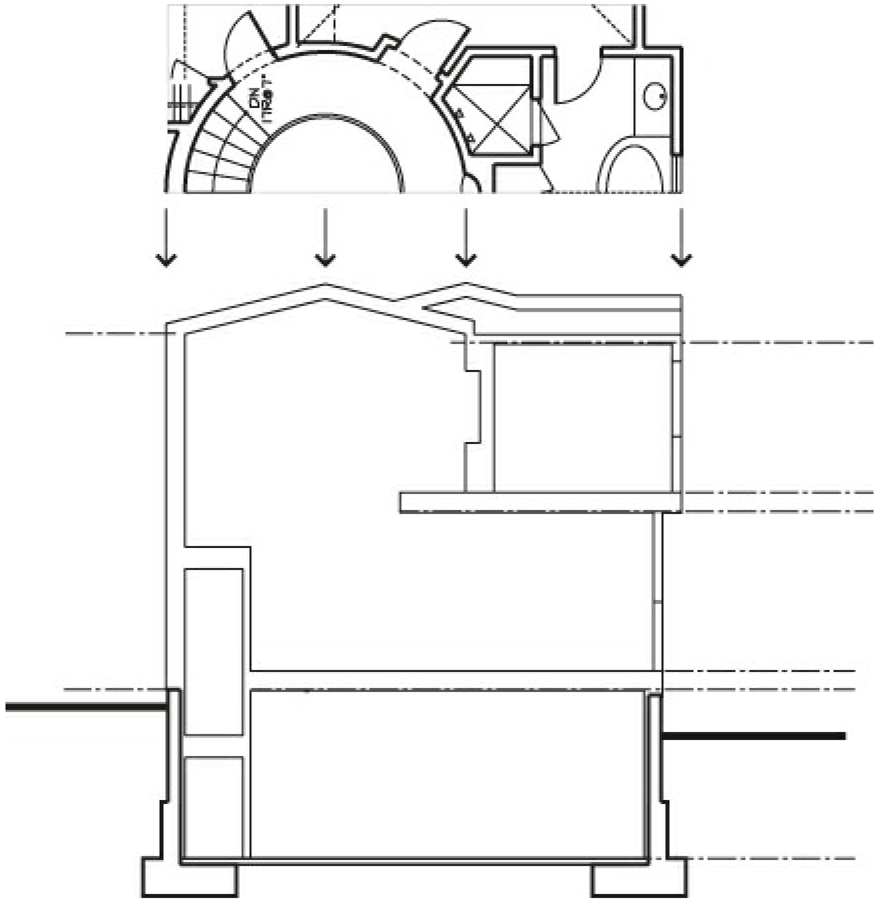
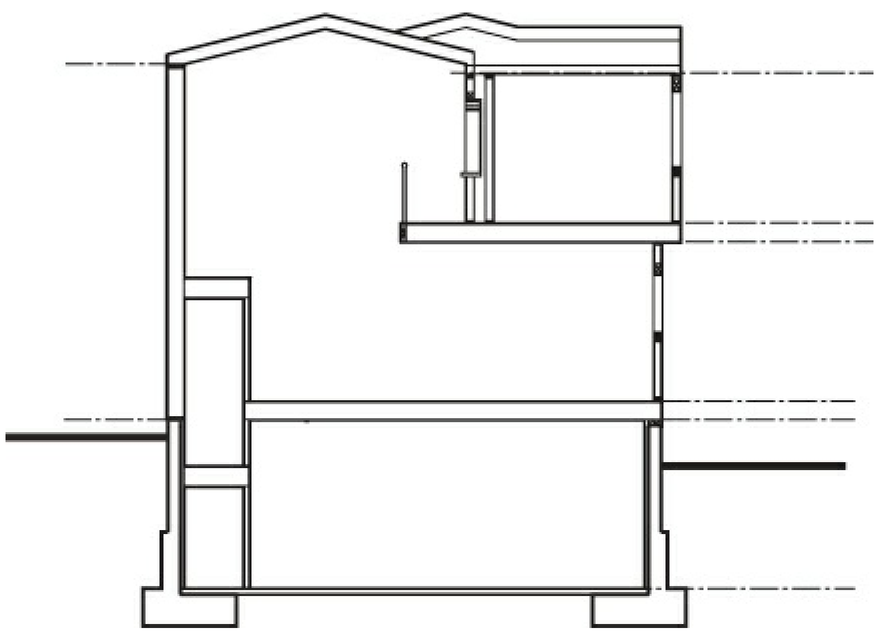


Figure 10.29 Stage II: Outlining of foundation, walls, and roof.



[Figure 10.30](#) Stage II: Aligning datum with floor plan.

Stage III ([Figure 10.31](#)). The thicknesses or widths of the foundation, walls, ceiling, and roof are drawn at this stage. Everything is drawn to net or actual size, not nominal size, to produce an accurate assembly drawing. Previously drafted details showing similar shapes and parts can be imported and used. This stage, which is actually a refinement of the Stage II drawing, constitutes the design development stage of a section.



[Figure 10.31](#) Stage III: Sizing members and outlining configuration.

Stage IV ([Figure 10.32](#)). This is said to be the most enjoyable stage because the

building begins to take on character with the addition of material designations and the array of the end views of ceiling joists, floor joists, and rafters. Concrete takes on its own character adjacent to grade (soil).

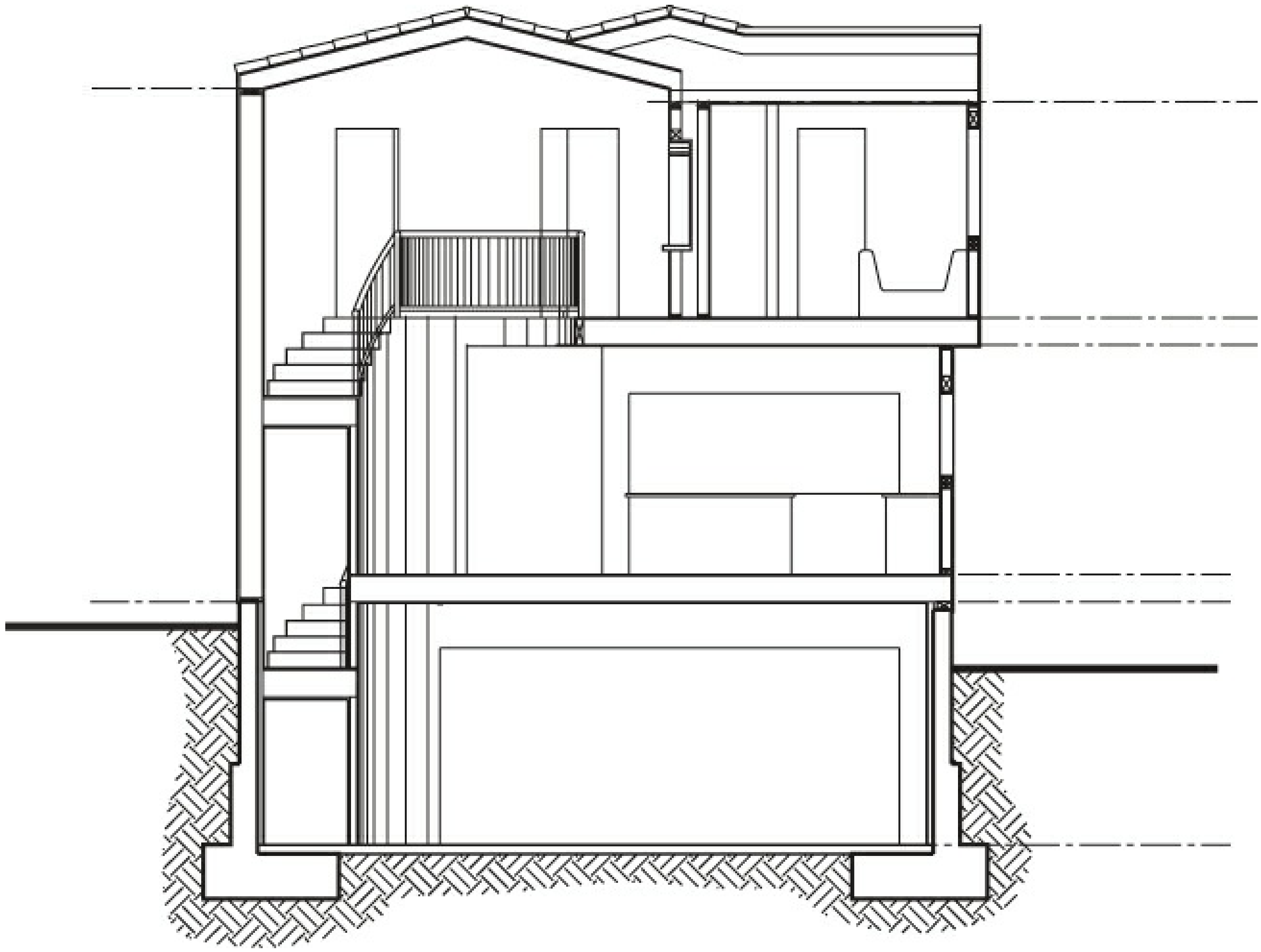


Figure 10.32 Stage IV: Materials designation, array joists.

Stage V (Figure 10.33). Stage V is the most critical to the accuracy of the project. All vertical dimensions are included at this stage. The most critical aspects are the dimensions for the floor to plate and definition of the neutral zones on the project. Horizontal dimensions should not appear in this stage, but rather on the floor plan, with the exception of describing the shape of a soffit or any other feature not seen in the floor plan. Note the call…out of elevation heights such as the top of subfloor 372.50′ (see Figure 10.33).

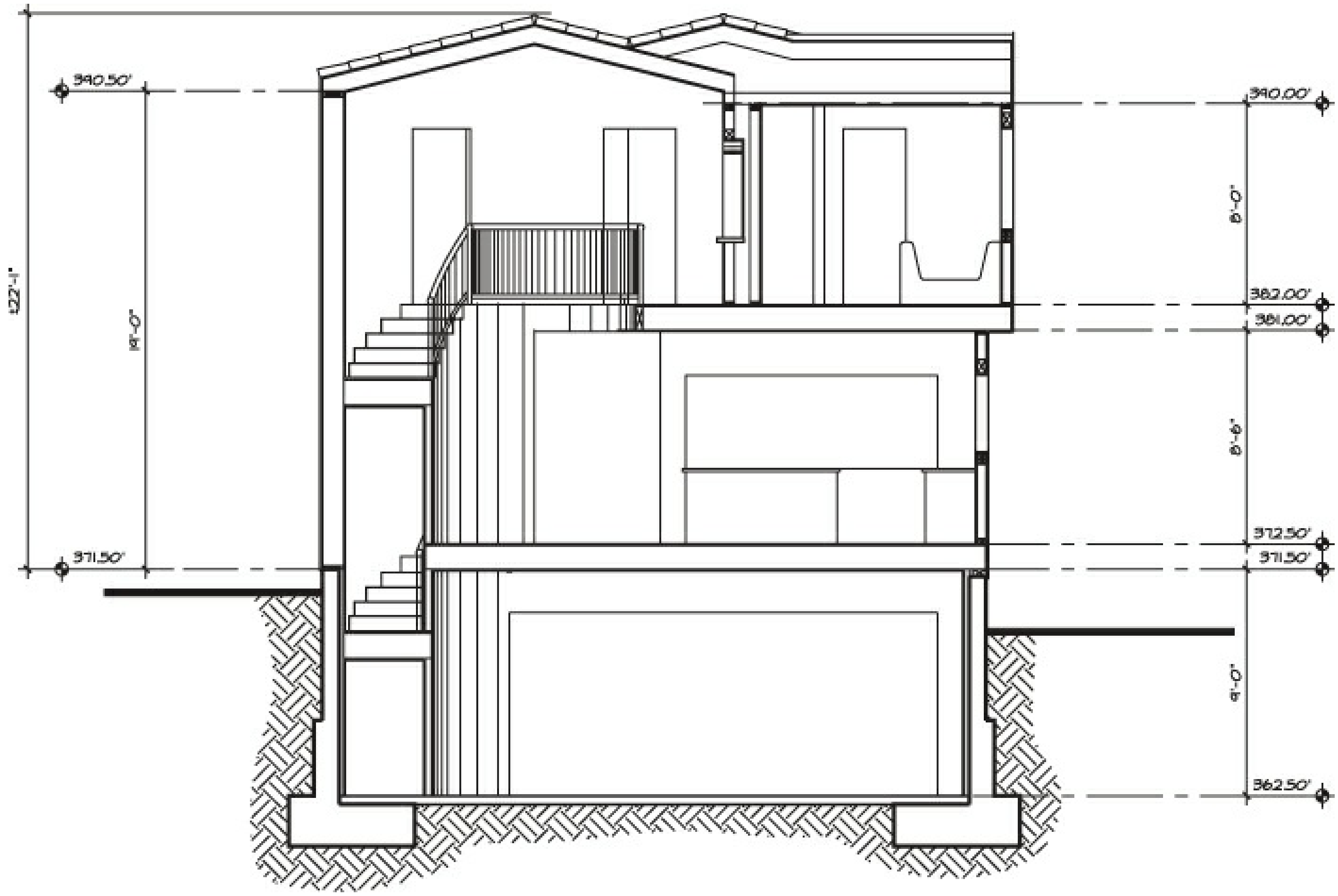


Figure 10.33 Stage V: Dimensioning.

Stage VI (Figure 10.34). All notes and referencing are included in this stage. Notes should be generic if the specific materials are described in the specifications. Titles must be given to all of the parts, including the names of rooms through which the section cut occurs. Reference bubbles are positioned and are referred to footing details, eave details, stair details, and so on. Remember, the **title** is a name given to this building section. If it is a full section, as in our example, two letters are used—for example, A…A, B…B, C…C. The first letter indicates the beginning of the section, and the second letter indicates the end of the cut.

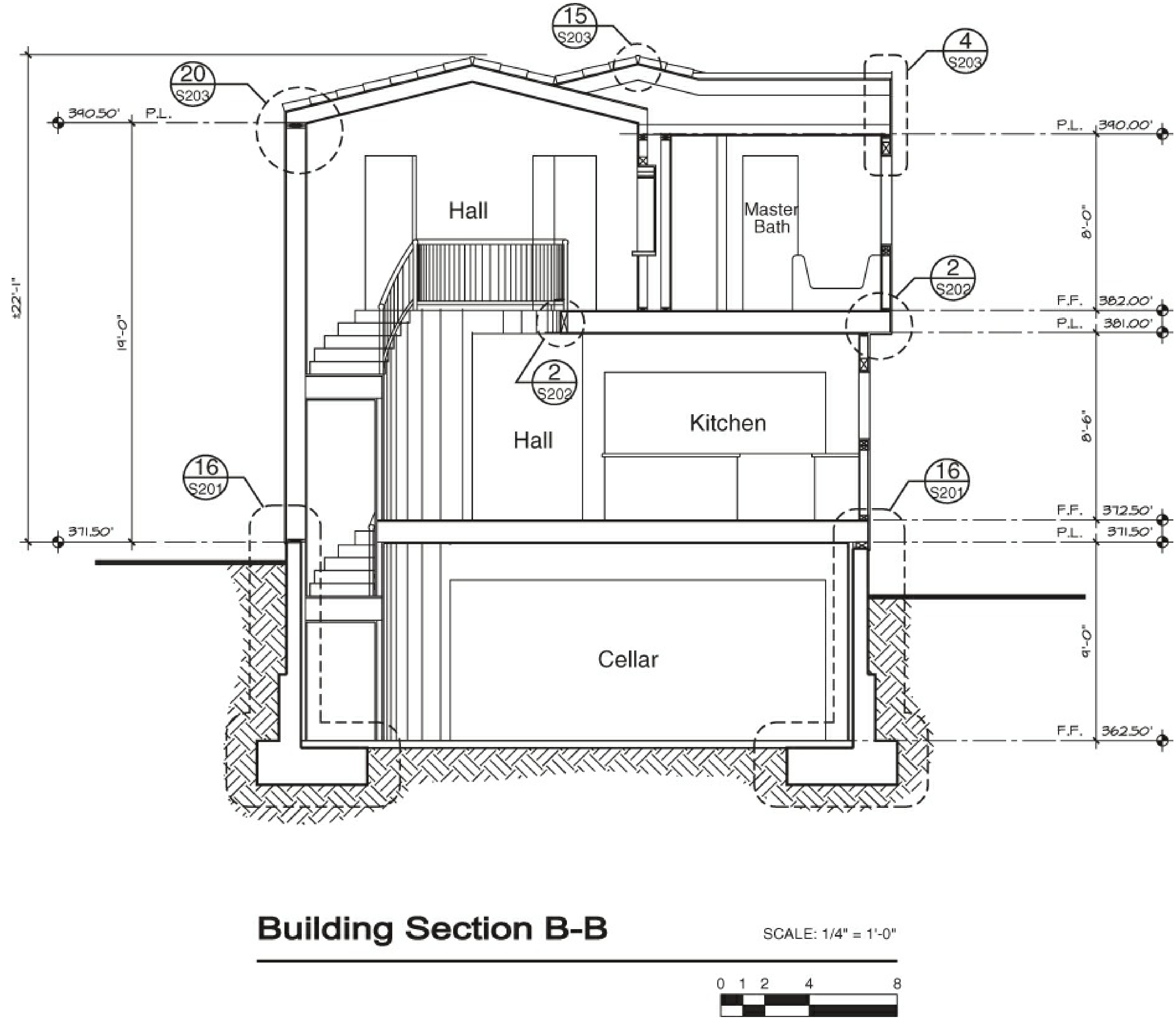
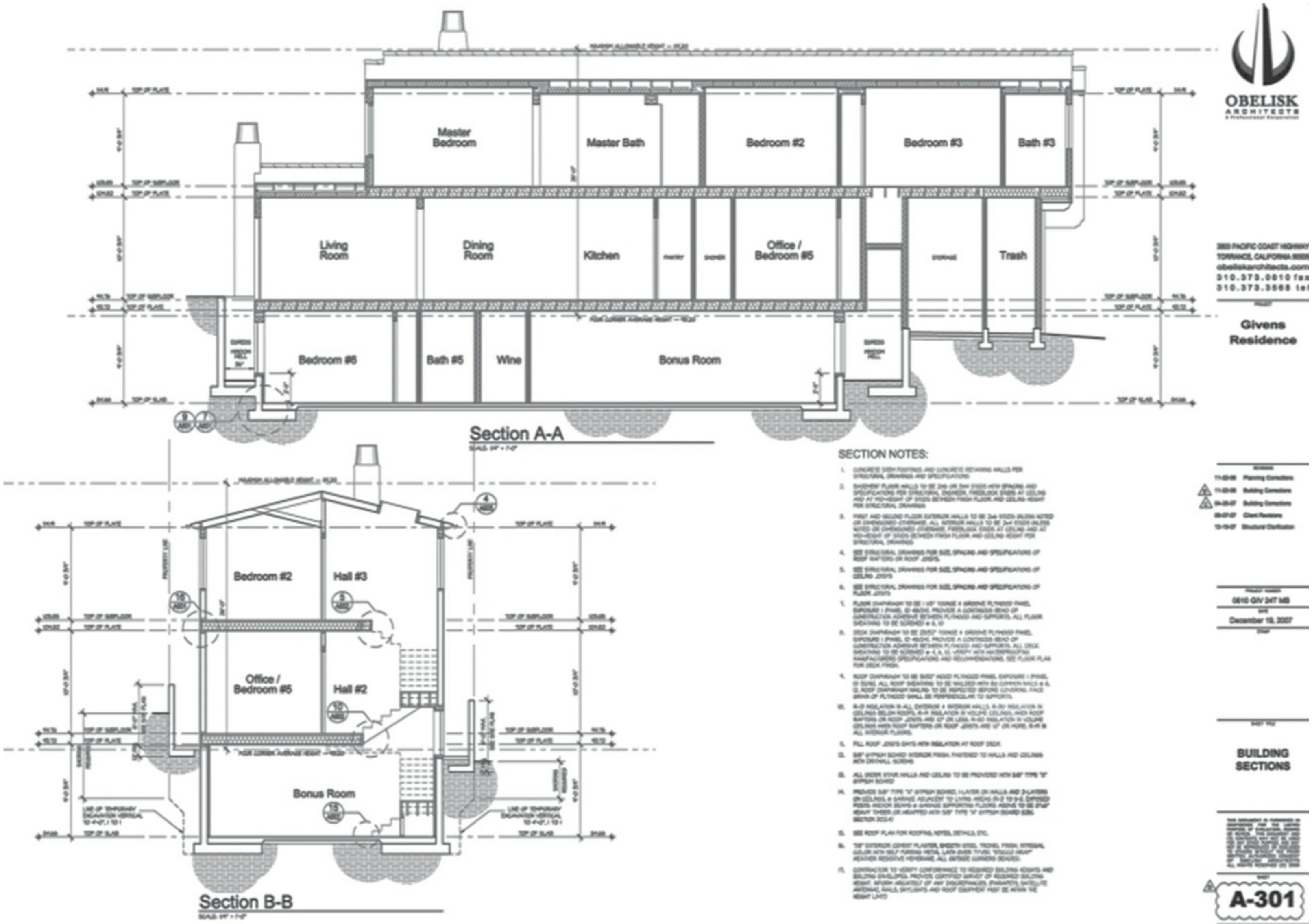


Figure 10.34 Stage VI: Noting, referencing, and titles.

(Courtesy of Mike Adli.)

The following two examples are completed sections that started as the design sections seen in Figures 10.13 through 10.16. Figures 10.35 and 10.36 are the completed sheets as presented to the client and to the Department of Building and Safety.



[**Figure 10.35**]() Completed sheet of building sections.

(Courtesy of Mr. & Mrs. Givens.)

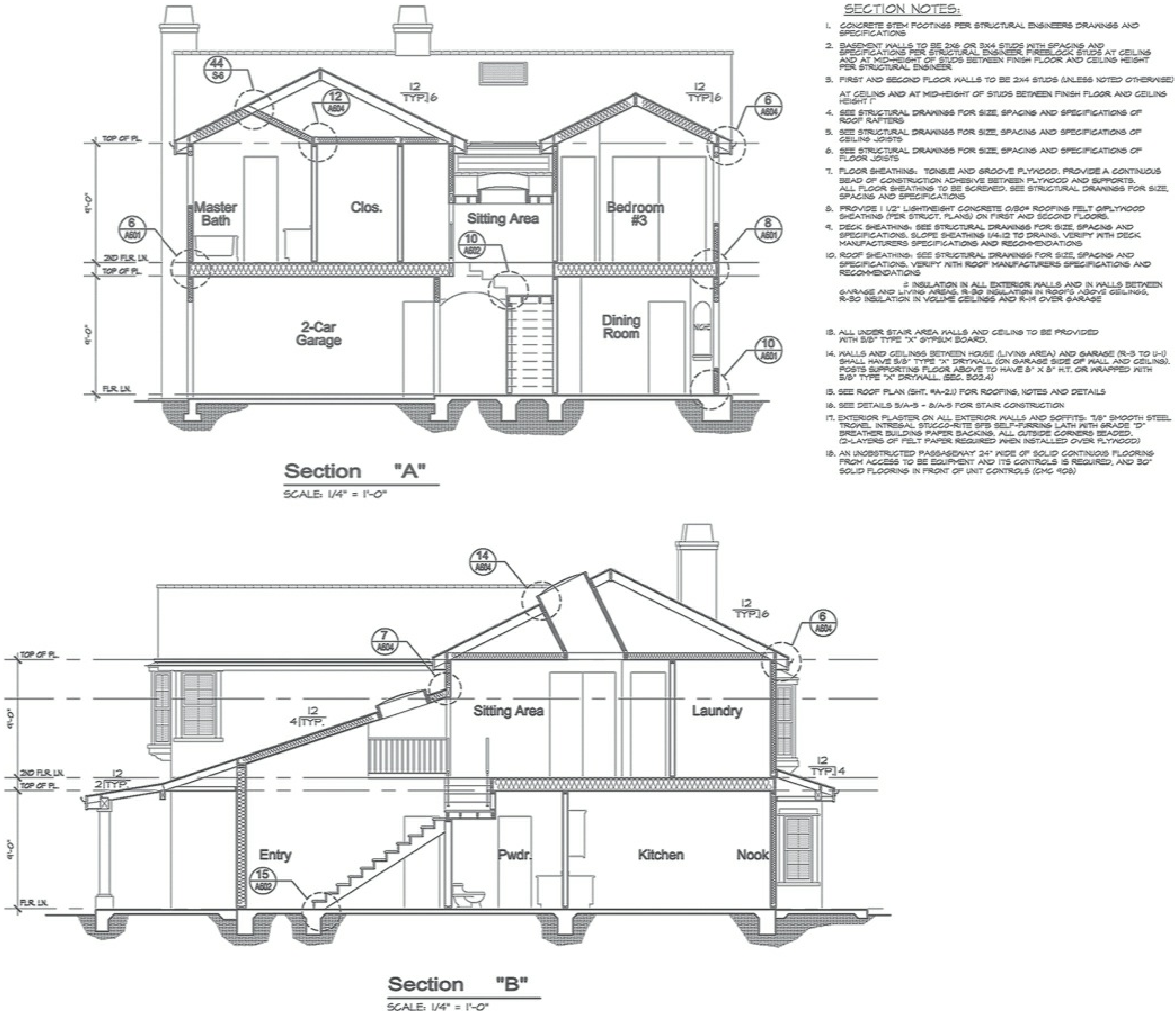


Figure 10.36 Completed sheet of building sections.

(Courtesy of John Katnik.)

Key Terms

building section

detail

plate

plate height

title

Chapter 11
EXTERIOR AND INTERIOR ELEVATIONS

EXTERIOR ELEVATIONS

Definition

The main purpose of **exterior elevations** is to describe the outer skin, and often the subskin, of the structure and show vertical dimensions that do not appear on any other drawing. Its datum is the floor…to…floor measurements and/or floor…to…plate measurements.

Purpose of Exterior Elevations. Throughout this chapter, you will find examples of drawings done to meet this purpose. Hand drawing and computer applications will be described. Here is a simple list of what you should do—and what drawing users will expect to find—on an exterior elevation of a simple residence:

1. Describe exterior materials found on the structure.
2. Provide a location for horizontal and vertical dimensions not found elsewhere.
3. Show, by using hidden lines, structural members found inside the walls. (Diagonal bracing is a good example of such hidden members.)
4. Show the relationship of elements, such as the height of the chimney in relationship

to the roof of the structure.

5. Incorporate reference bubbles for building, window, and door sections.
6. Show any exterior design elements that cannot be shown elsewhere.
7. Show stepped footings, if there are any.
8. Describe building finishes and colors.

Basic Approach. In mechanical or engineering drafting, the elevations are described as the front, side, and rear. In architecture, exterior elevations are called *north, south, east,* and *west*. See Figure 11.1. Figure 11.2 shows how we arrive at the names for exterior elevations.

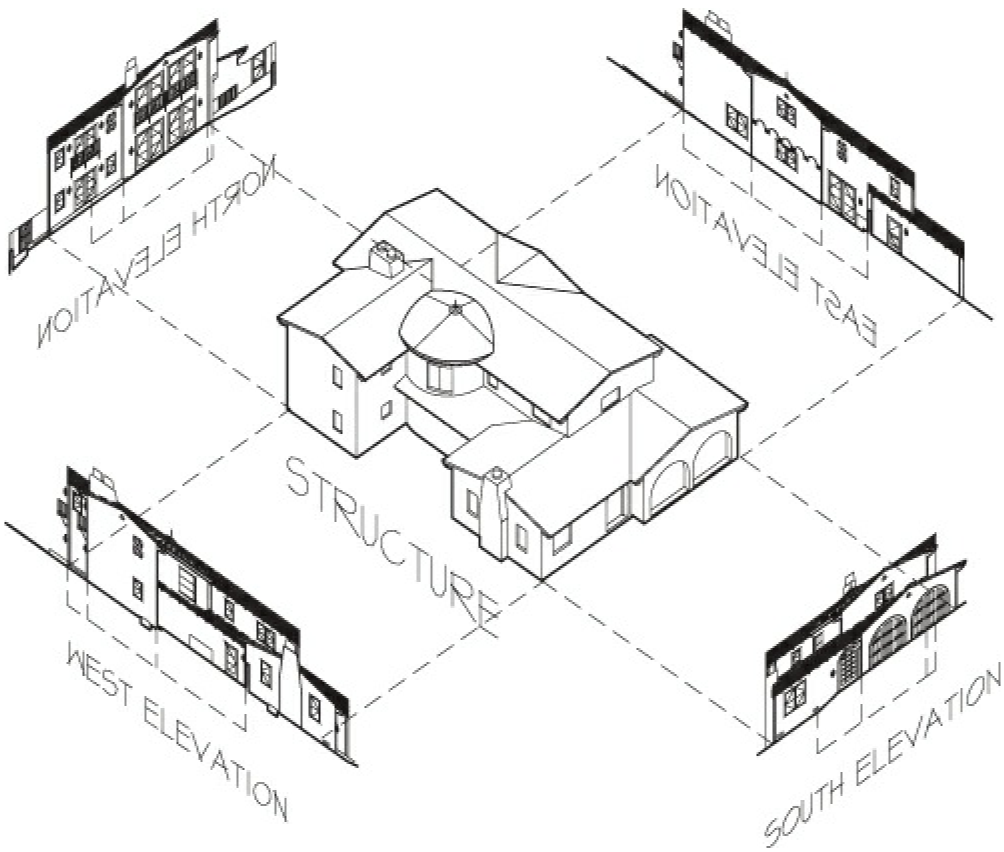


Figure 11.1 Multiview drawing of a structure.

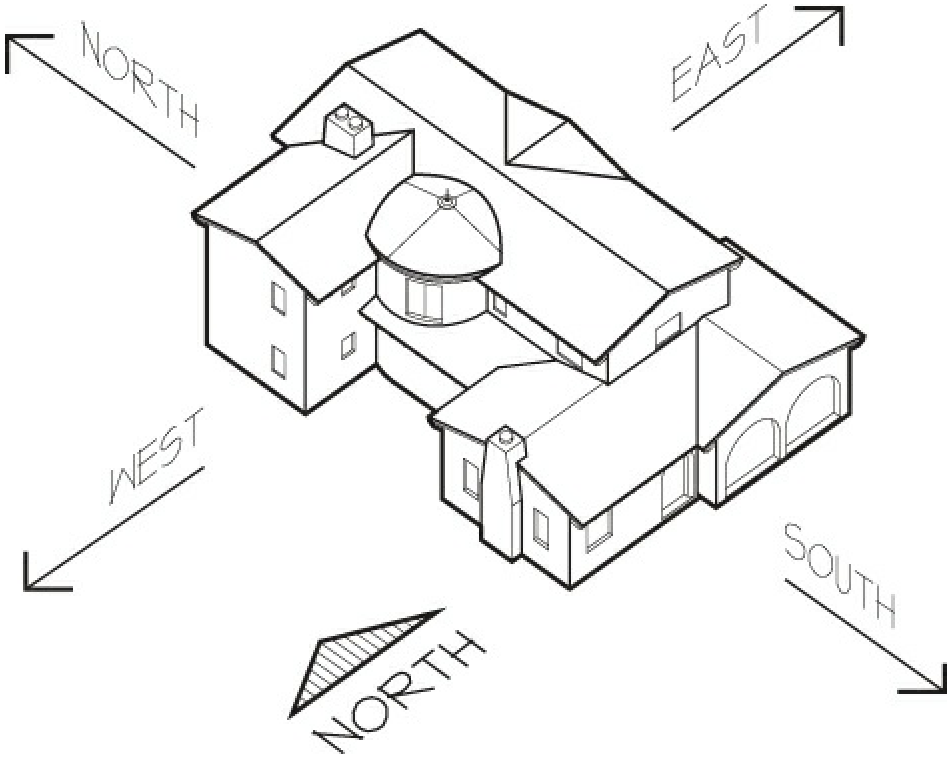


Figure 11.2 Names of elevations.

Orientation. The north, south, east, and west elevations may not be true directions (e.g., not true north or true east). They may have been taken from an “orientation north,” or, as it has been called in other regions, *plan north*, which may not be parallel to true north. When the boundaries of a structure are not parallel with true north, an orientation north is established, and used from then on to describe the various elevations. See Figure 11.3.

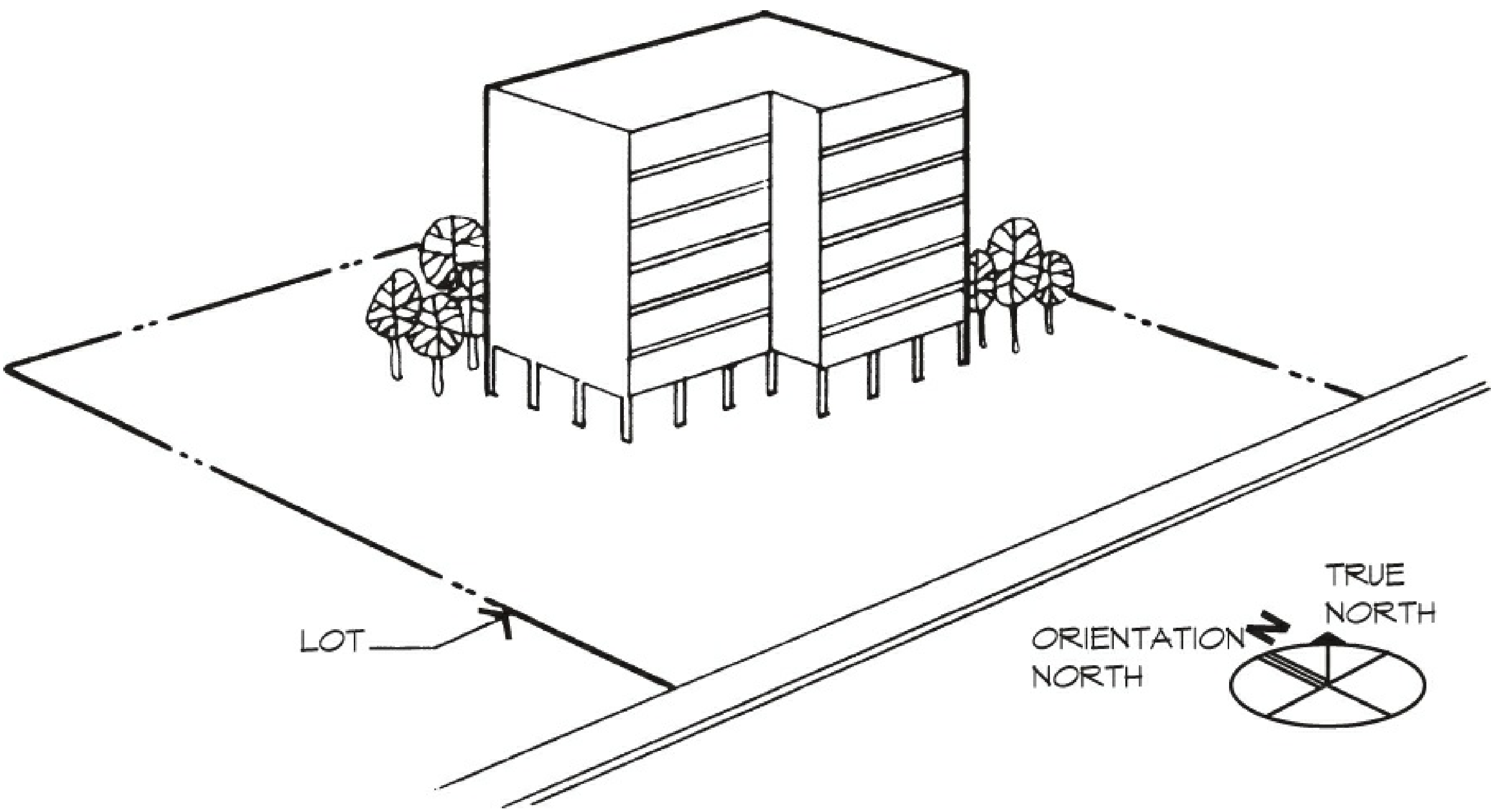


Figure 11.3 Use of orientation north.

These terms, then, refer to the direction the structure is facing. In other words, if an elevation is drawn of the face of a structure that is facing south, the elevation is called the *south elevation;* the face of the structure that is facing west is called the *west elevation,* and so on. Remember, the title refers to the direction the structure is facing, *not* to the direction in which you are looking at it.

Finally, because of the size of the exterior elevations, they are rarely drawn next to the plan view as in mechanical drafting. See Figure 11.4.

Figure 11.4 Elevation arrangement.

(Courtesy of Mike Adli.)

Method 1: Direct Projection. You can draft exterior elevations by directly projecting sizes from the plan views or sections. Figure 11.5 shows how elevations can be directly projected from a plan view (a roof plan, in this case). Figure 11.6 shows how the heights are obtained. Locations of doors, windows, and other details are taken from the floor plan. Figure 11.7 shows a slightly more complex roof being used to form the roof shape on an elevation.

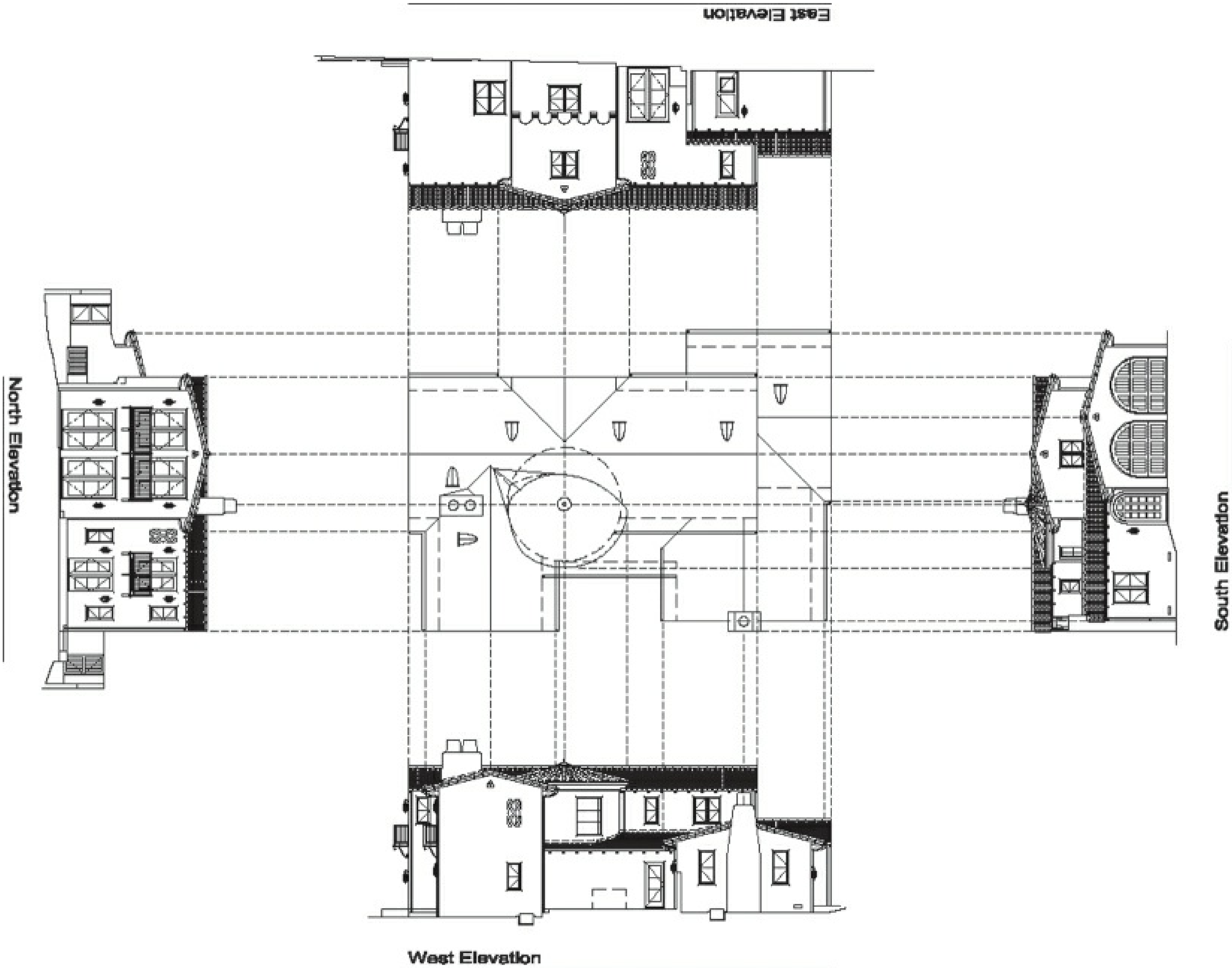


Figure 11.5 Obtaining width and depth dimensions.

Figure 11.6 Heights from wall sections.

(Courtesy of Mike Adli.)

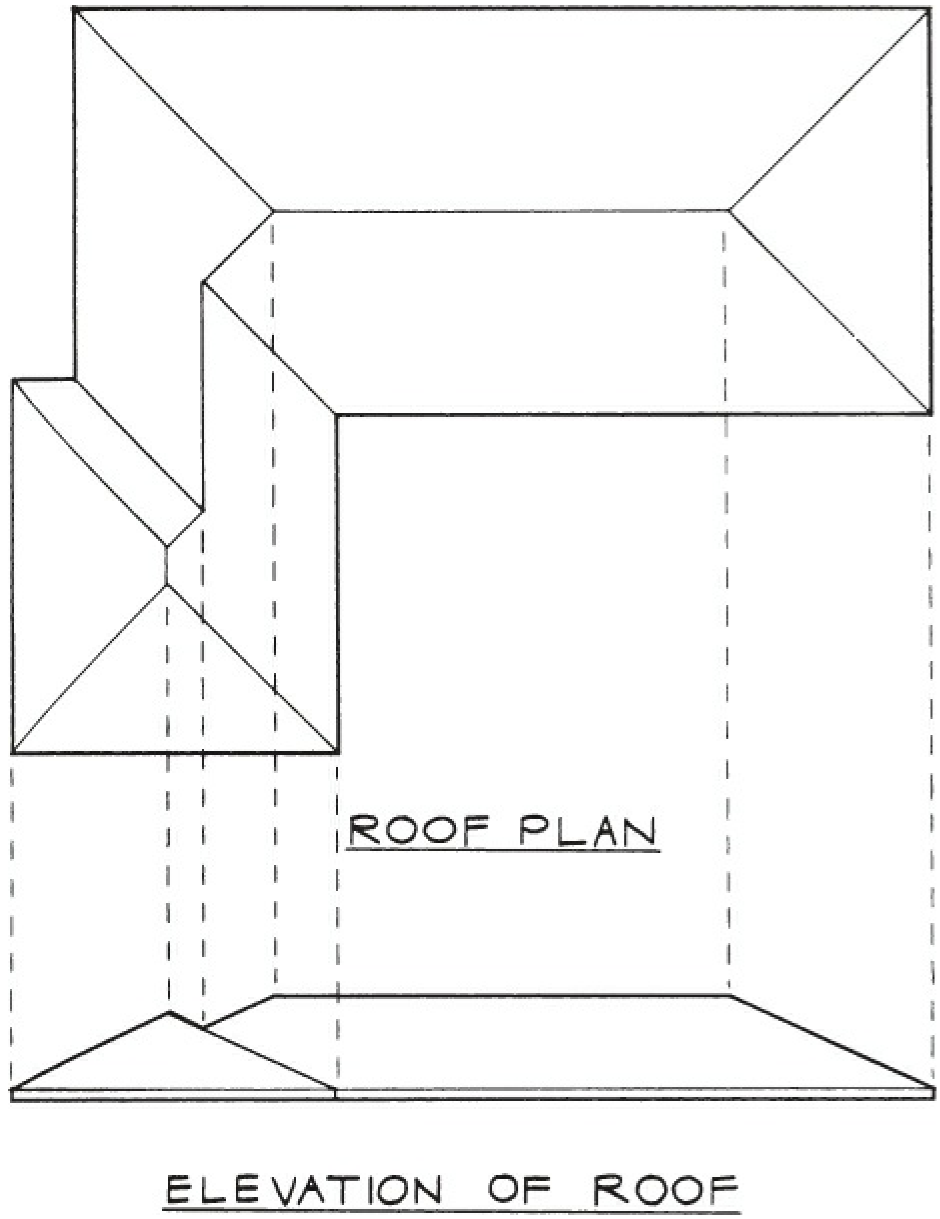


Figure 11.7 Roof elevation from roof plan.

Method 2: Dimensional Layout. You can also draft exterior elevations by taking the dimensions from the plans and sections and drafting the elevation(s) from scratch. First, lightly lay out the critical vertical measurements. In the example shown in Figure 11.8, these measurements are the *subfloor* (top of plywood or concrete) line and the *plate line* (top of the two top plates above the studs). See Figure 11.9A. This measurement is taken directly from the building section.

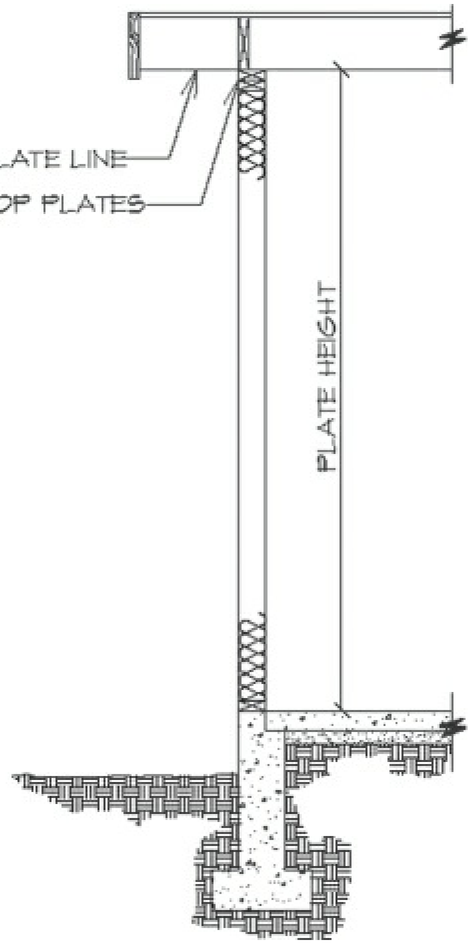


Figure 11.8 Establish plate height.

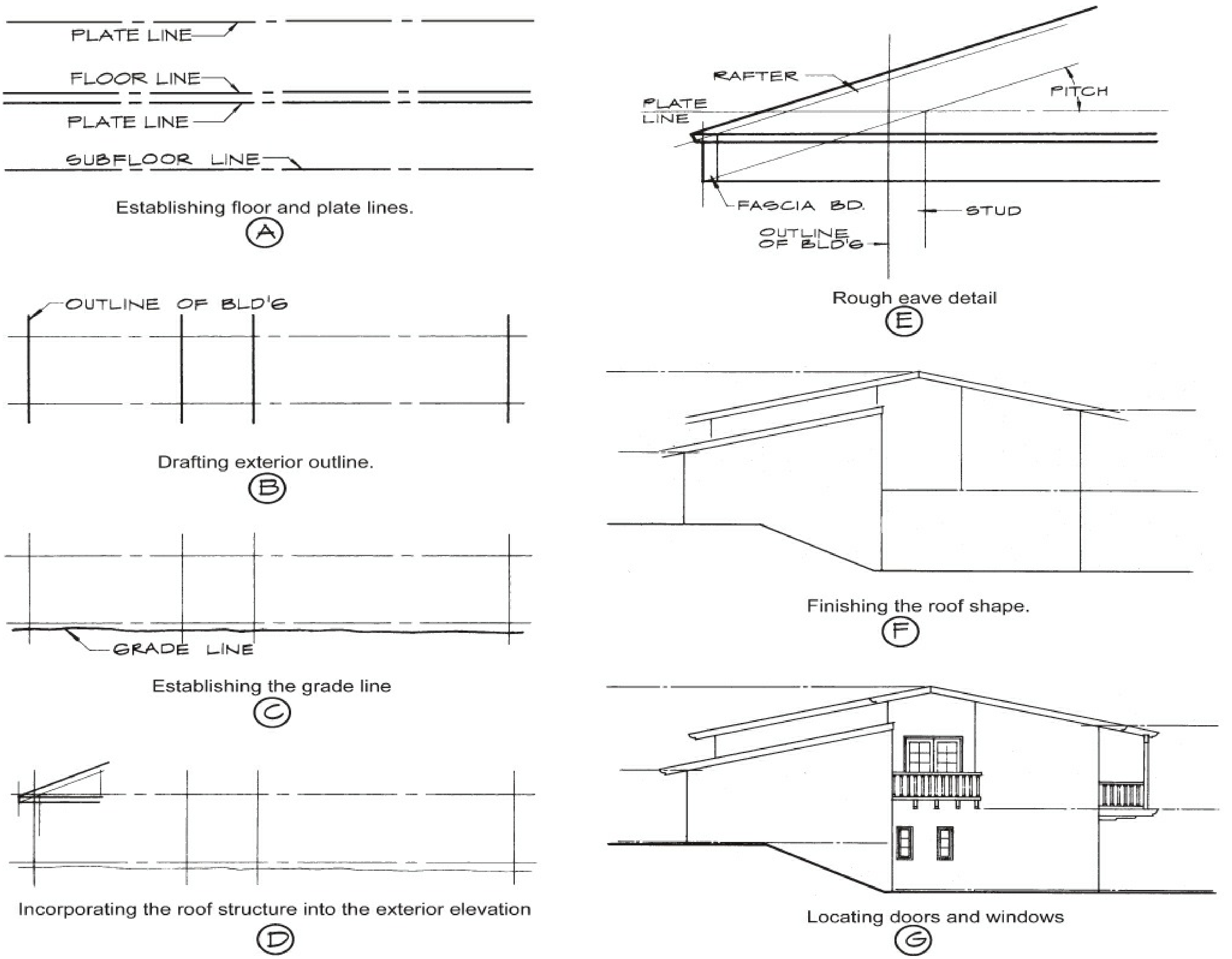


Figure 11.9 Using a visual and written checklist.

The second step establishes the location of the walls and offsets in the structure from the floor plan. Draw these lines lightly, because changes in line length may be required later. See Figure 11.9B.

Third, establish the grade line (earth) in relationship to the floor line. See Figure 11.9C. This dimension is from the building sections or footing sections.

Next, as Figure 11.9D shows, add the roof configuration. To better understand the relationship between the roof and the rest of the structure, draw the **eave** (portion of a roof that extends beyond the wall) in a simple form, as shown in Figure 11.9E. These dimensions are found on the building section. The finished roof shape depends on the roof framing plan or the roof plan for dimensions. See Figure 11.9 F.

Finally, windows and doors are located. Sizes are found on the window and door schedule, and locations on the floor plan. Material designations, dimensions, notes, and structural descriptions complete the elevation. See Figure 11.9G.

Figure 11.10 shows a typical example of an exterior elevation. Go back to the beginning of

the chapter and compare Figure 11.10 with the simple list of elements.

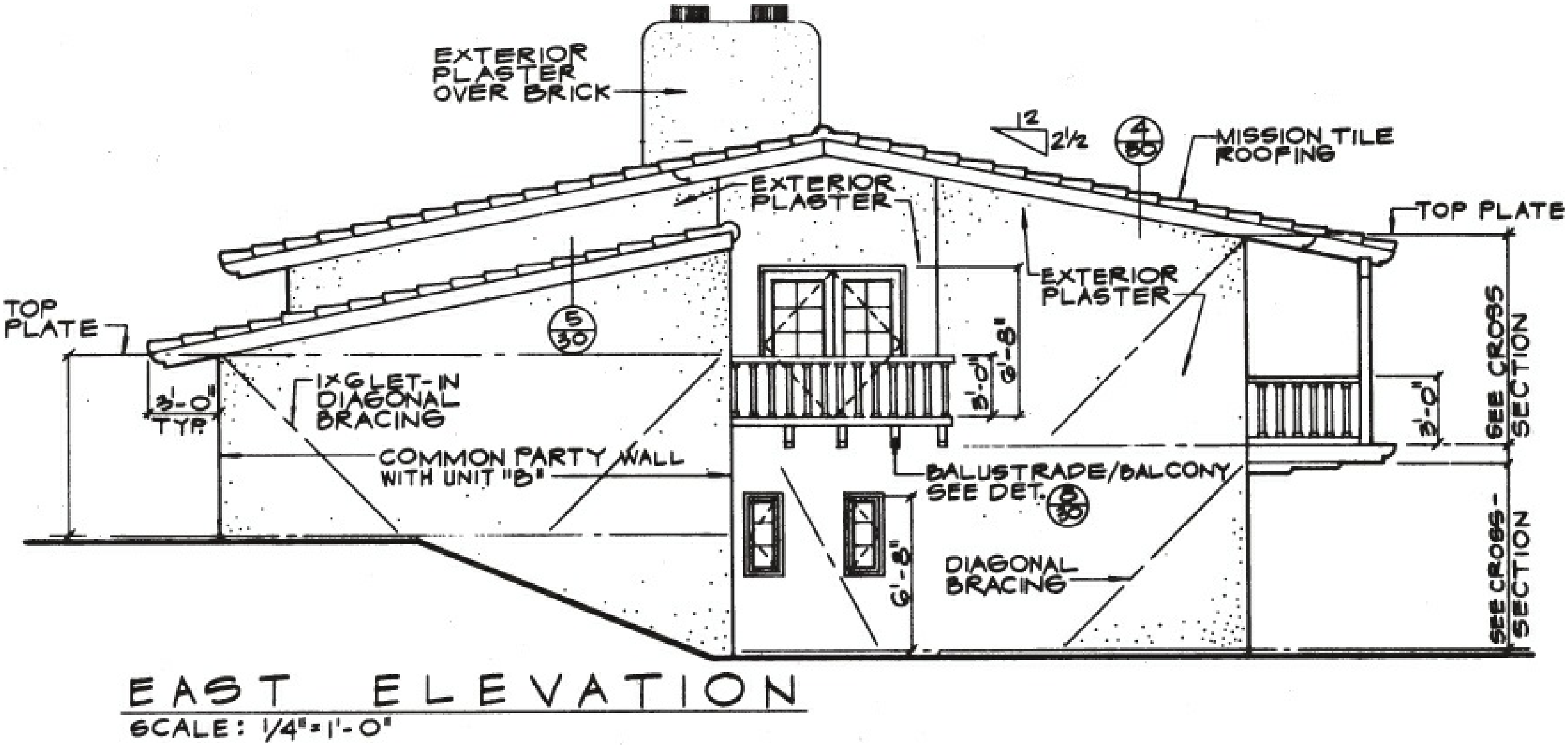


Figure 11.10 Drafted east elevation of a condominium.

(Courtesy of William F. Smith—Builder.)

Choice of Scale. Selection of the scale for elevations is based on the size and complexity of the project and the available drawing space. For small structures, ¼″ = 1′…0″ is a common scale. For a larger project, a smaller scale can be used. The exterior elevation is usually drawn at the same scale as the floor plan. For medium and large elevations, you may have to decrease the scale in relationship to the floor plans.

Because we are dealing with small structures, two to four stories in height, we are using the largest scale allowed by the available drawing space not exceeding ¼″ = 1′…0″.

Odd_Shaped Plans. Not all plans are rectangular; some have irregular shapes and angles. Figure 11.11 shows several building shapes and the north designation. For these kinds of conditions, all elevations are drawn.

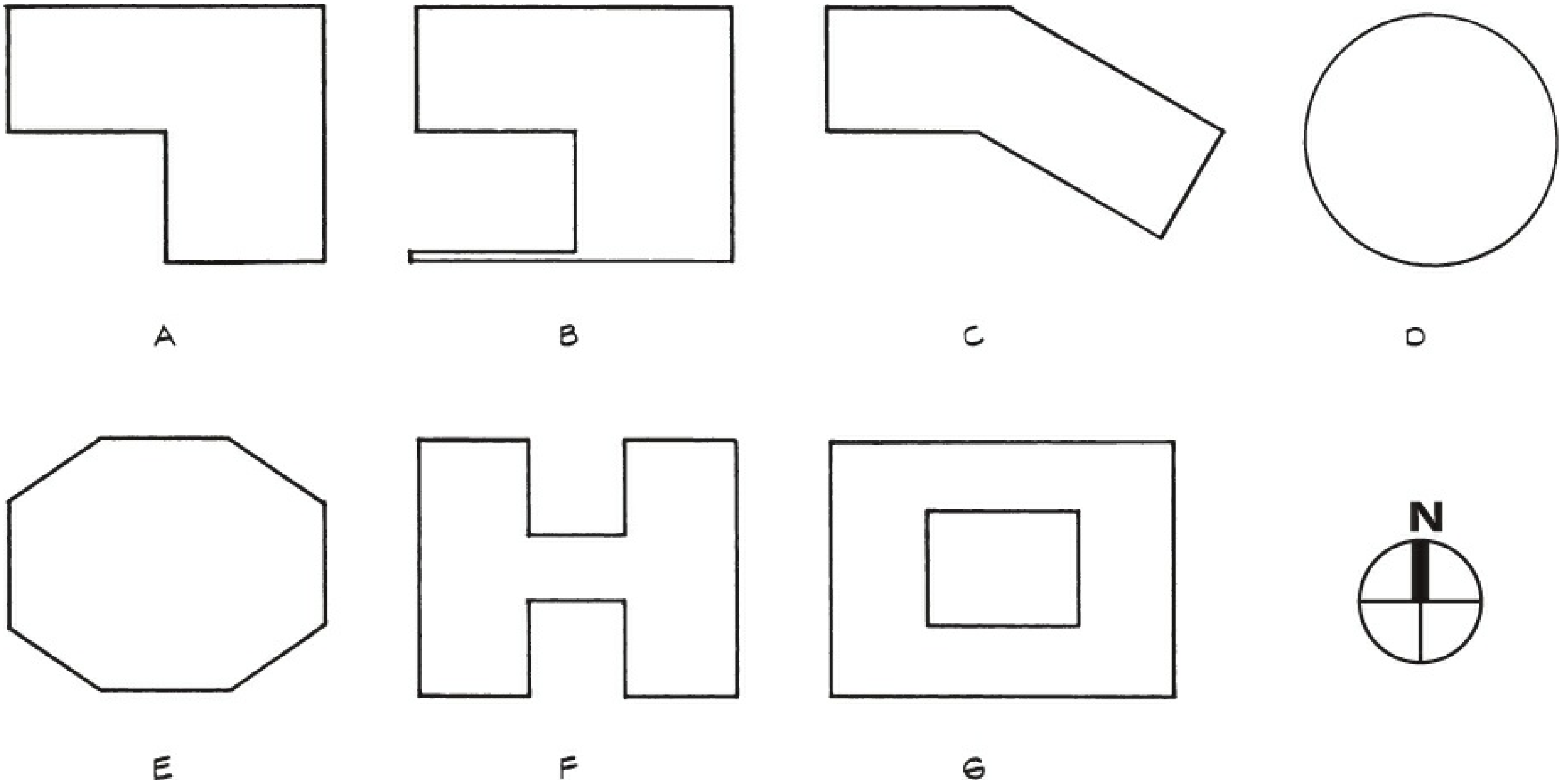


Figure 11.11 Irregularly shaped plans.

Shape A. Figure 11.12 shows the exterior elevations for a relatively simple L…shaped building and how these elevations were obtained using the projection method.

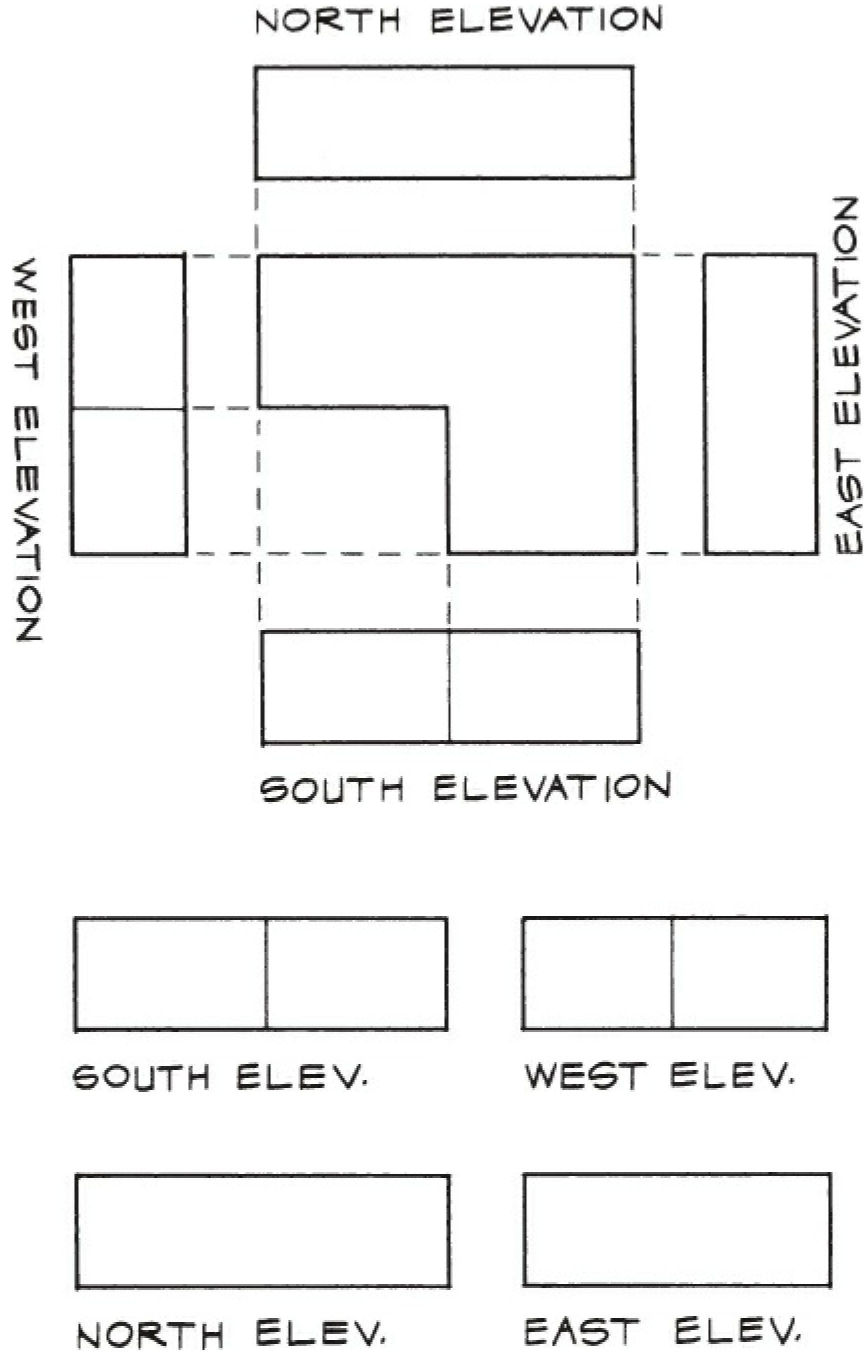


Figure 11.12 Elevations for Shape A.

Shape B. The elevations for Shape B in Figure 11.13 present a unique problem on the east and particularly the south elevation. Because the fence is in the same plane as the south side of the structure, include it in the south elevation. Had the fence been in front of the structure, you could either delete it or include it in order to show its relationship to the structure itself.

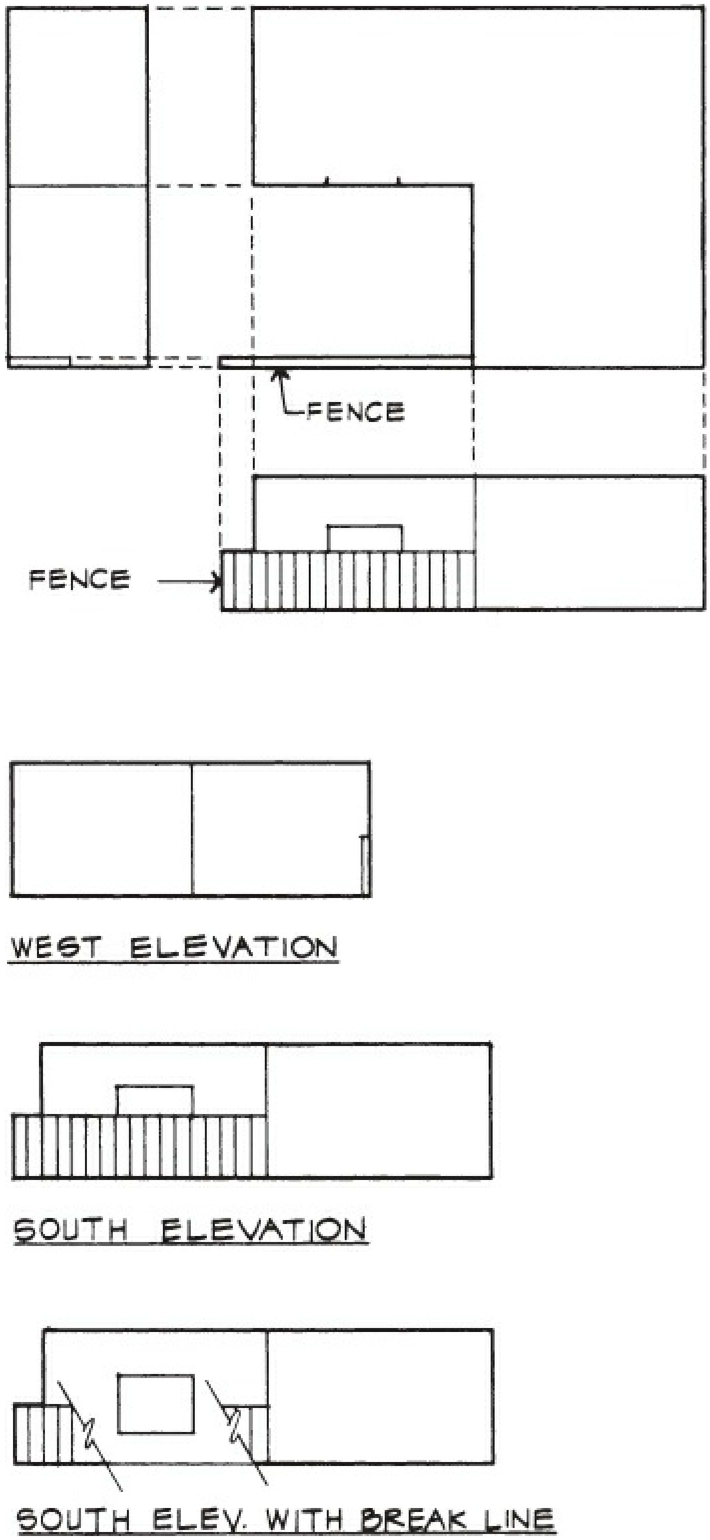


Figure 11.13 Elevations for Shape B.

The inclusion of the fence may pose additional problems, such as preventing a view of portions of the structure behind. You can overcome this difficulty in one of two ways: either eliminate the fence altogether (not show it) or use a break line, as shown in Figure 11.13. This allows any item behind it, such as the window, to be exposed, referenced, and dimensioned. Break lines still allow dimensioning and descriptions of the fence.

Shape C. The two portions on the right of the south elevation and all of the east elevation are *not* true shapes and sizes because they are drawn as direct 90° projections from the *left* portion of the plan view. This is sometimes a problem. See Figure 11.14. The

west and north elevations will also be distorted. See Figure 11.11.

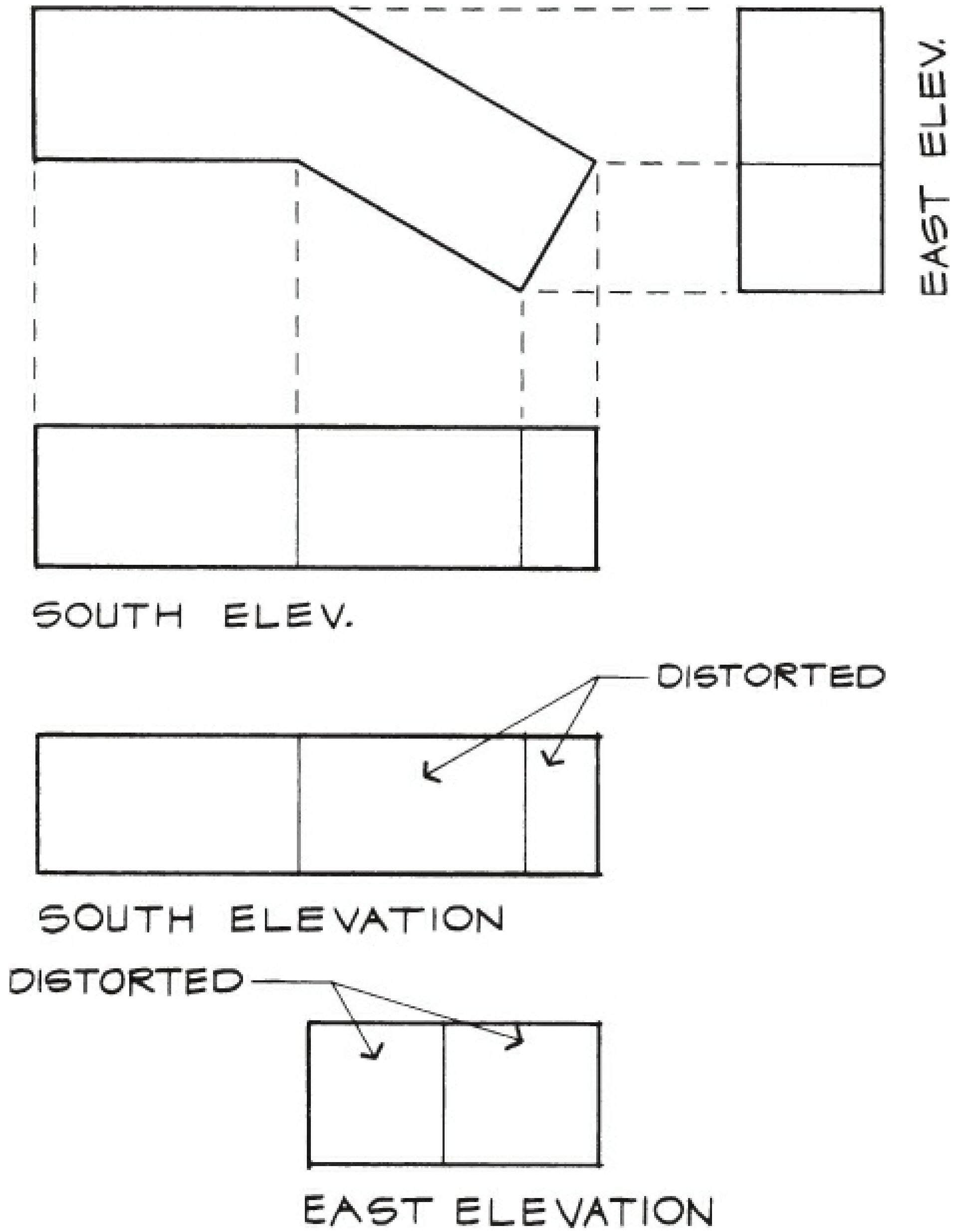


Figure 11.14 Elevations for Shape C.

To solve this problem, we use an *auxiliary view:* a view that is 90° to the line of sight. The elevations are projected 90° to the sight lines, and a break line is used to stop the portion that is not true. Notice on Figure 11.15 how the break line splits the south elevation into two parts. Each part is projected independently of the other, and its continuation, which is not a true shape, is voided.

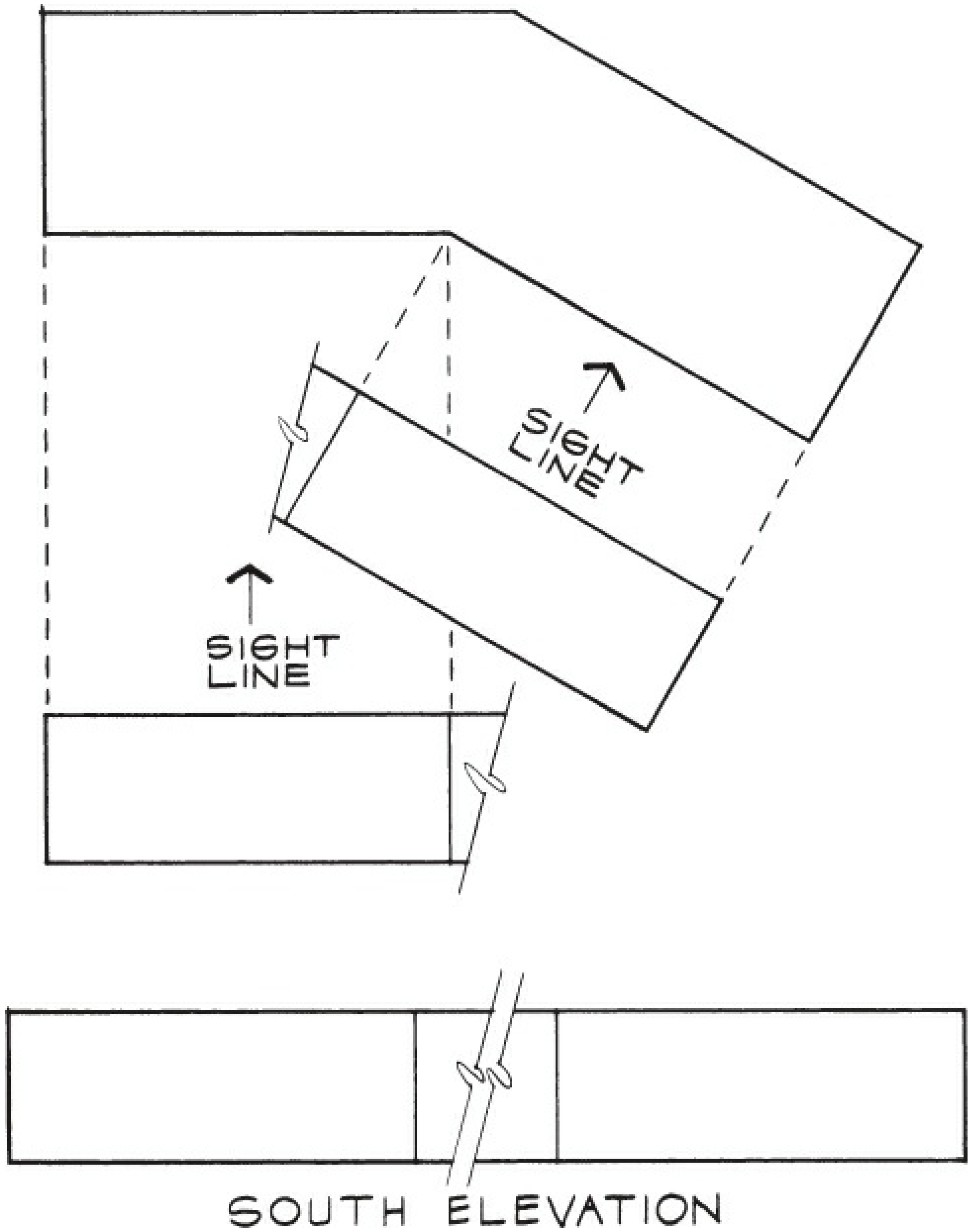


Figure 11.15 Elevations with new sight line.

(William Boggs Aerial Photography. Printed with permission.)

The south elevation in Figure 11.14 appears to have three parts rather than two, as in Figure 11.15. In the latter case, the third part will be left to the east elevation. With a more complex shape, a break line beyond the true surface being projected can be confusing. See Figure 11.16. To avoid confusion, introduce a *pivot point* (P.P.; the point at which the end of one elevation becomes the beginning of another elevation), and show it as a dotted (hidden) line or a centerline…type line (dots and dashes). See Figure 11.17.

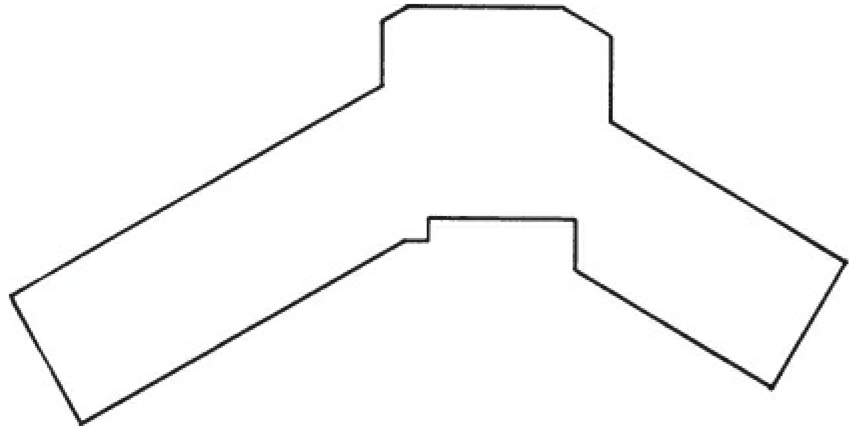


Figure 11.16 Complicated shape.

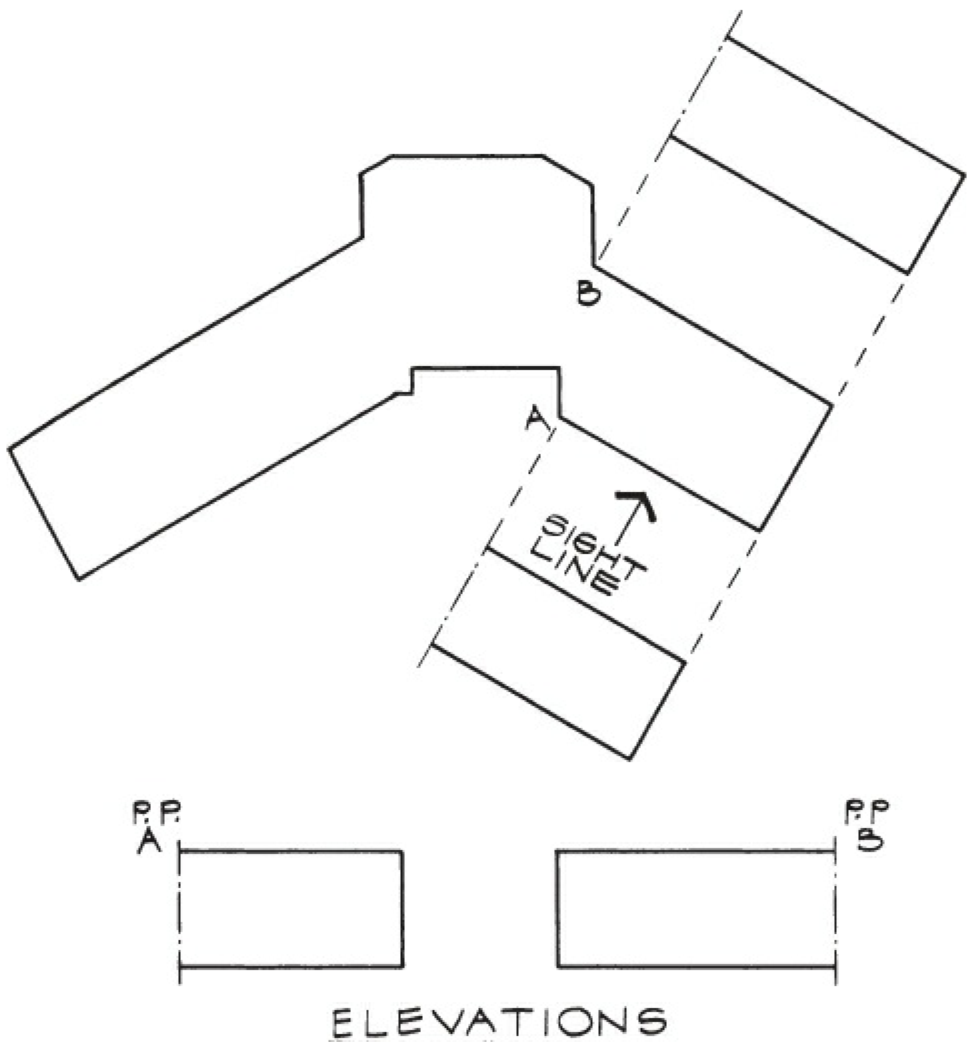


Figure 11.17 Use of pivot point in exterior elevations.

Pivot points can cause a problem in selecting a title for a particular elevation. To avoid confusion, introduce a *key plan*. The key plan is usually drawn on the bottom right corner of the drawing sheet. See Figure 11.18. Draw and label a reference bubble for every necessary elevation. These reference bubbles will become the titles for the elevations. If the surface contains important information about the structure or surface materials, it deserves a reference bubble. Figure 11.19 shows how these elevations are represented with titles and pivot…point notations.

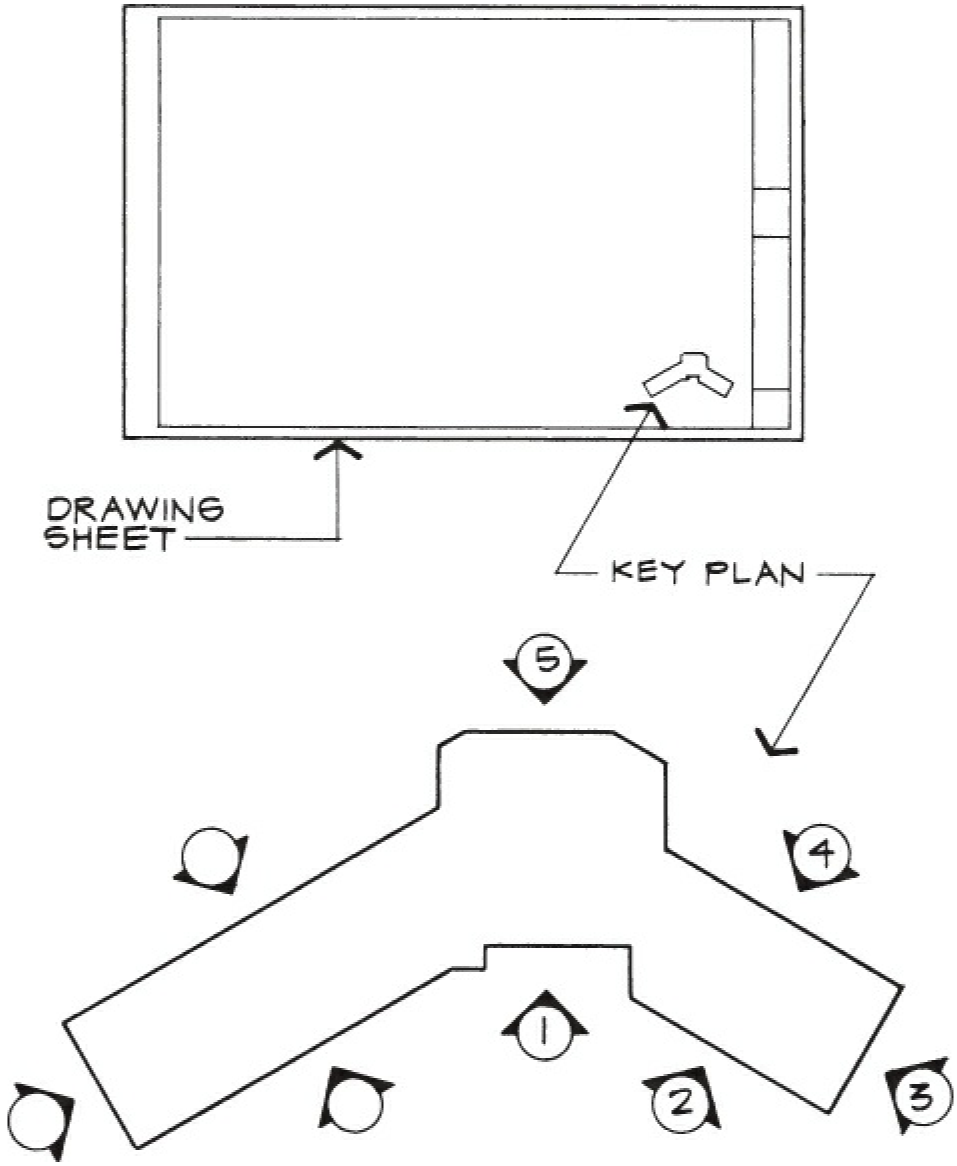


Figure 11.18 Using a key plan.

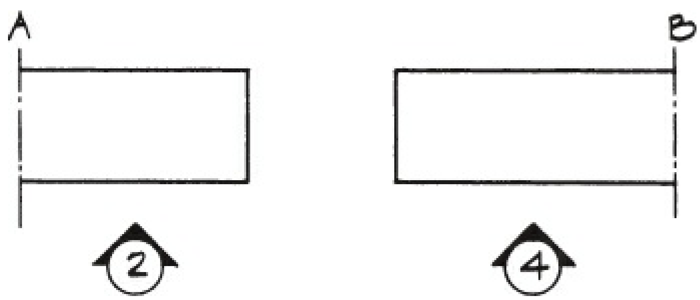


Figure 11.19 Elevations using key plan.

Shape D. With shape D from Figure 11.11, nothing is true shape or size, regardless of the direction of the elevation. See Figure 11.20. Figure 11.21 shows a pivot point together with a *fold*‥*out* (called a *development drawing* in mechanical drawing).

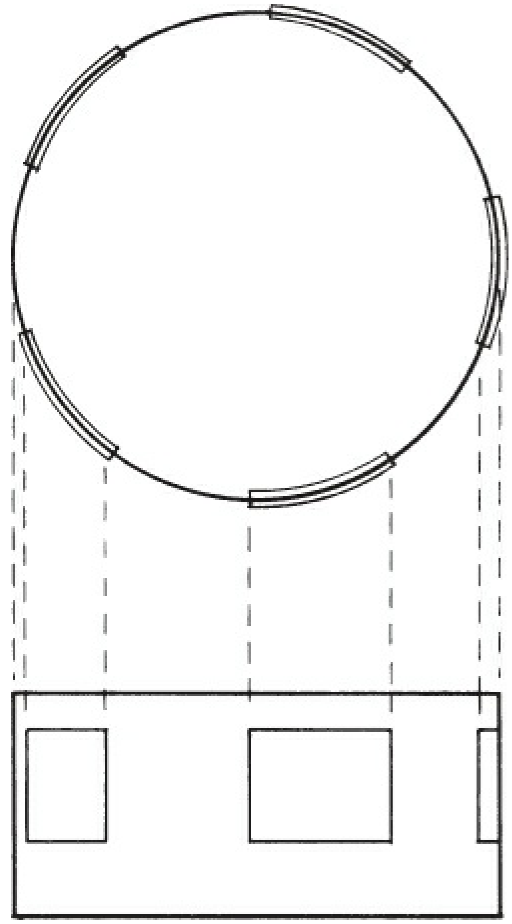


Figure 11.20 Elevations of a cylinder.

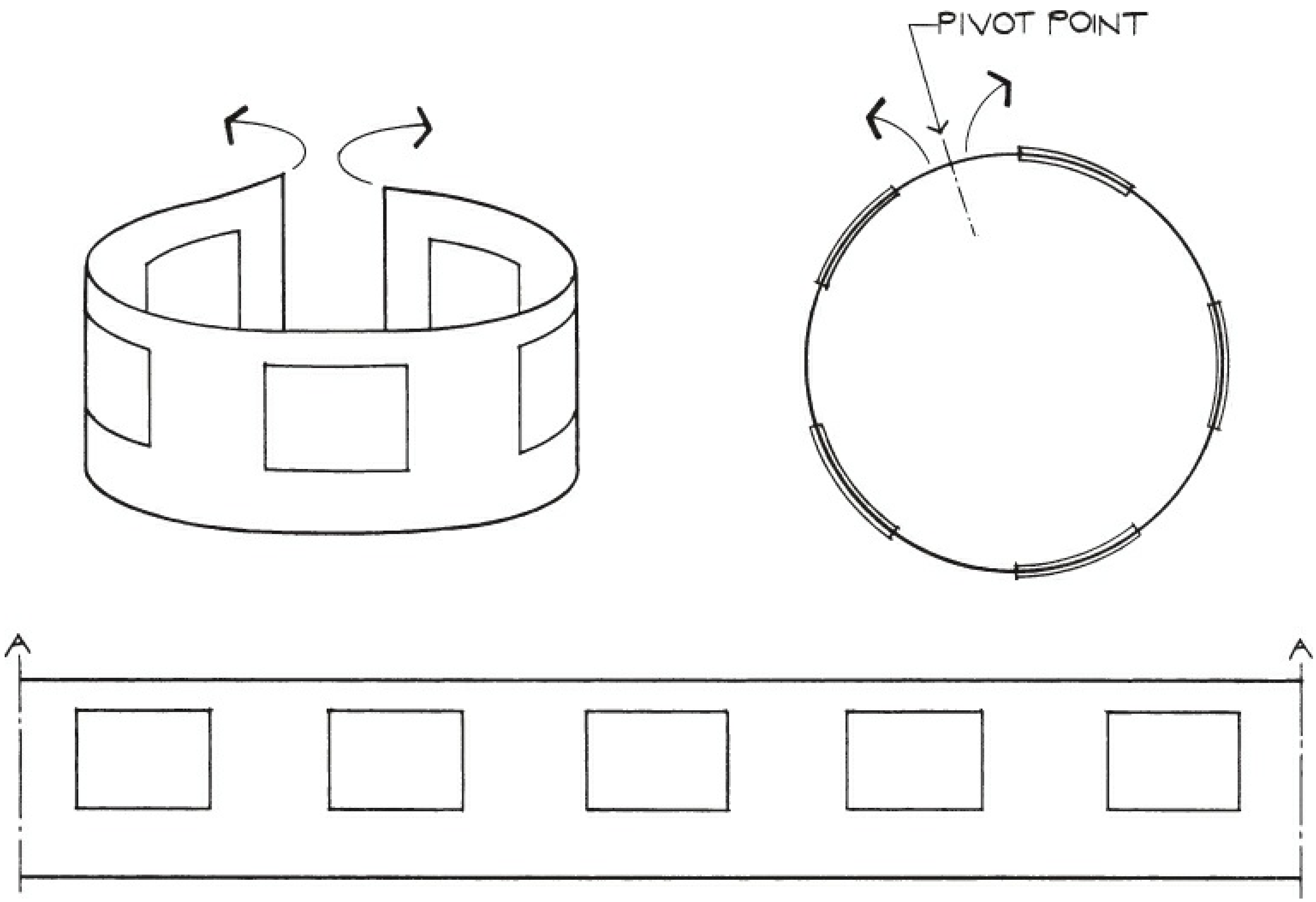


Figure 11.21 Elevation of cylinder using pivot point.

Shape E. Shape E in Figure 11.11 can be drawn in one of three ways: first, by drawing it as a direct projection so that one of the three exposed faces will be in true shape and size; second, by using a key plan and drawing each surface individually; and third, by drawing it as a fold…out similar to Figure 11.21. Choose the method that will best explain the elevations. For example, if all other sides are the same, the direct…projection method may be the best. If every wall surface is different, then the key plan or fold…out method would be best.

Shape F. Surfaces that will be hidden in a direct projection, such as some of the surfaces of shape F in Figure 11.11, can effectively be dealt with in one of two ways. The first uses a key plan and the second uses a combination of an elevation and a section. Both methods are shown in Figure 11.22. The combination of the section and the elevation shows the structure and its relationship to the elevation more clearly.

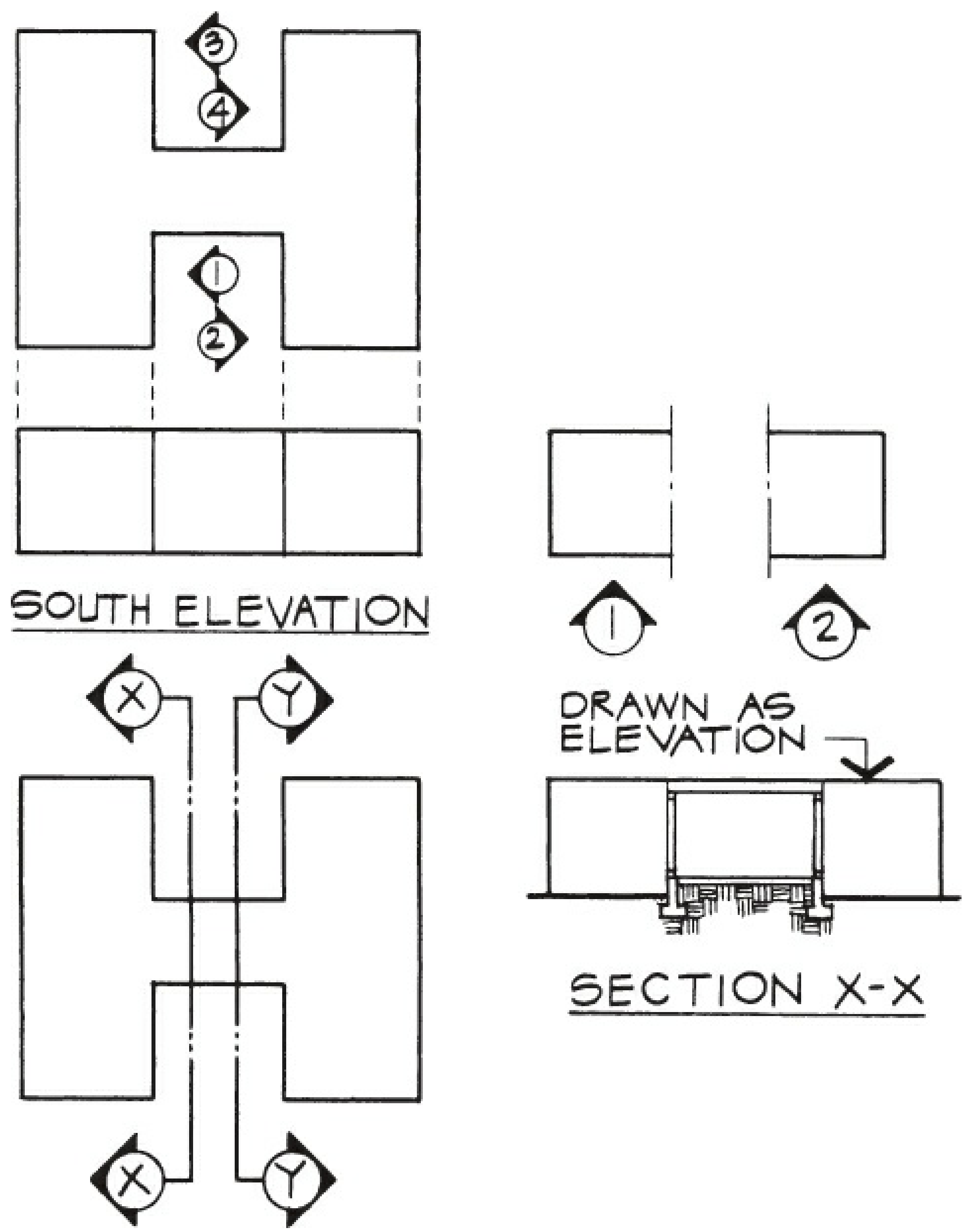


Figure 11.22 Elevations for shape F.

Shape G. Shape G in Figure 11.11 can be drawn simply as the south elevation, north elevation, east elevation, and west elevation using a direct‐projection method. The interior space (atrium) can also be drawn as a direct projection with titles "Atrium North Elevation," "Atrium South Elevation," "Atrium East Elevation," and "Atrium West Elevation." A way to simplify this is shown in Figure 11.23.

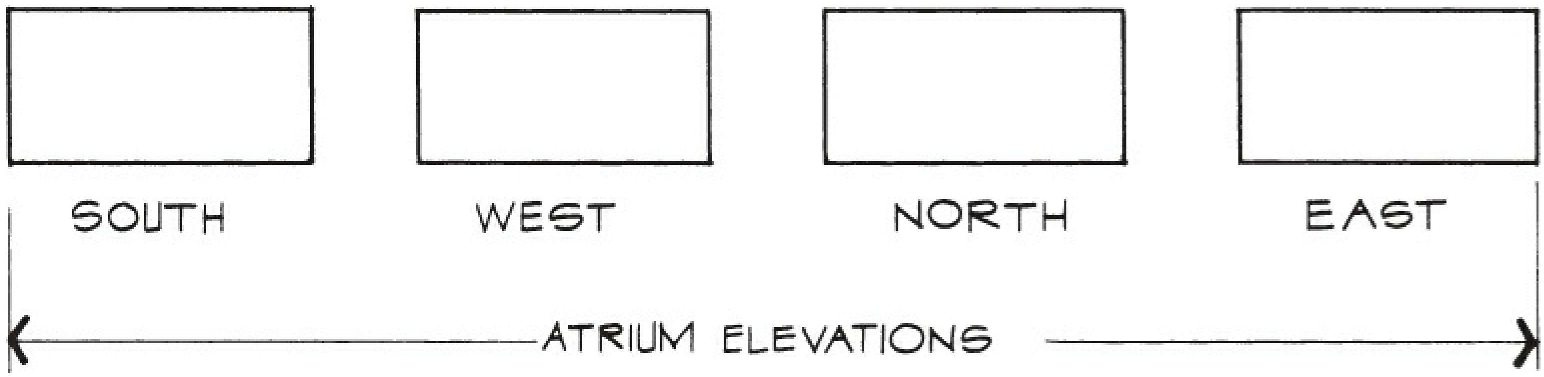
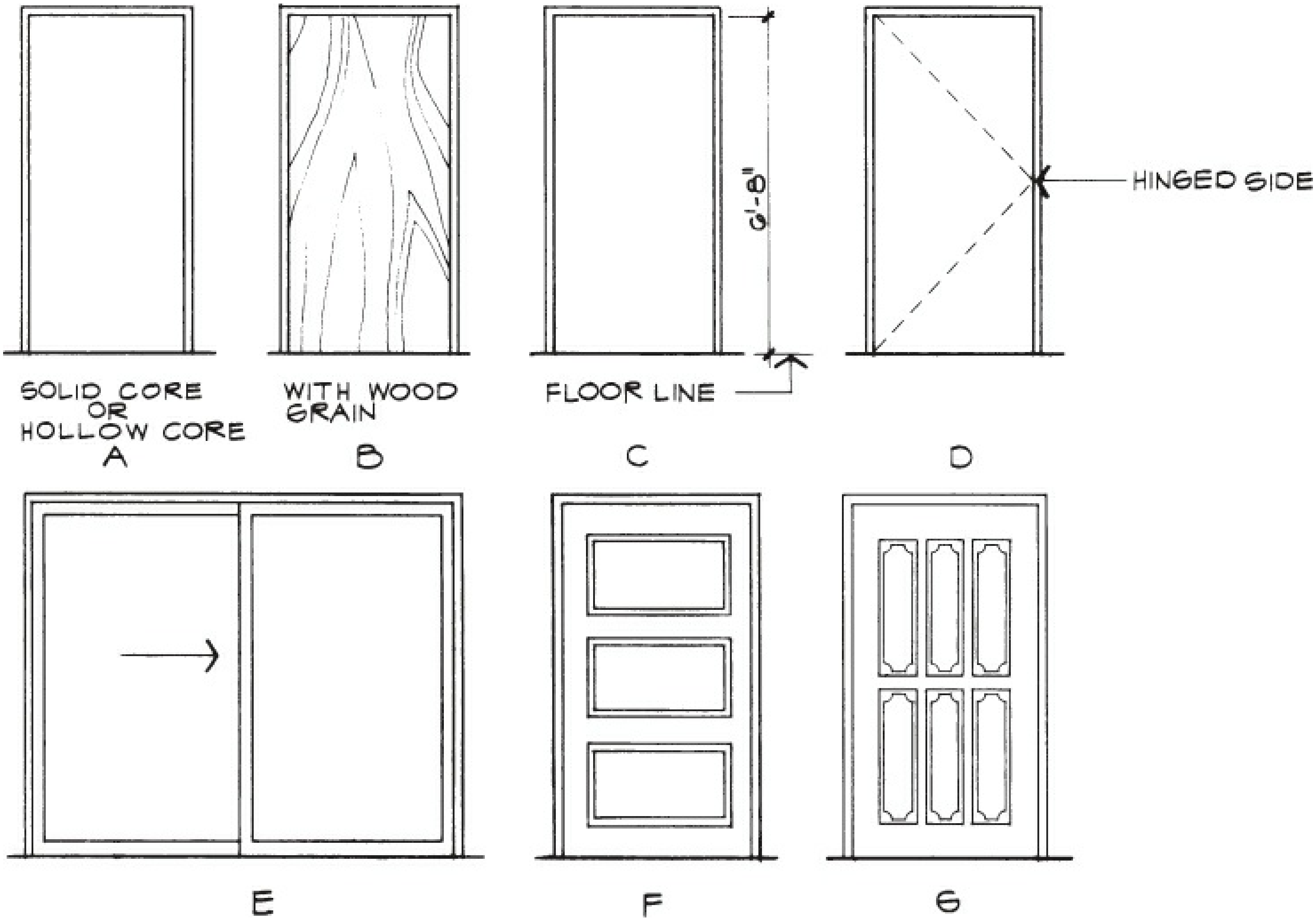


Figure 11.23 Simplified elevation titles.

Drawing Doors and Windows. Draw doors and windows on elevations as close as possible to the actual configuration. Horizontal location dimensions need not be included, because they are on the floor plan; likewise, door and window sizes are contained in the door and window schedule. However, vertical location dimensions are shown with indications of how the doors and windows open.

Doors. Doors and their surface materials can be delineated in various ways. Illustrations A and B in Figure 11.24 show the basic appearance of a door with and without surface materials—wood grain, in this instance. Illustration C shows the final configuration of a dimensioned door. Note that the 6′‐8″ dimension is measured from the floor line to the top of the floor. The other line around the door represents the trim. For precise dimensions for the trim, consult the door details. Illustrations D and E of Figure 11.24 show how a door opens or slides. Panel doors are shown in illustration F, and *plant‐on doors* (doors with decorative pieces attached) are shown in illustration G.



[Figure 11.24](#) Doors in elevation.

Windows. Windows are drafted much like doors. Their shape, their operation, and the direction in which they open are represented. Double…hung windows and louver windows are obvious exceptions because of their operation. See [Figure 11.25](#).

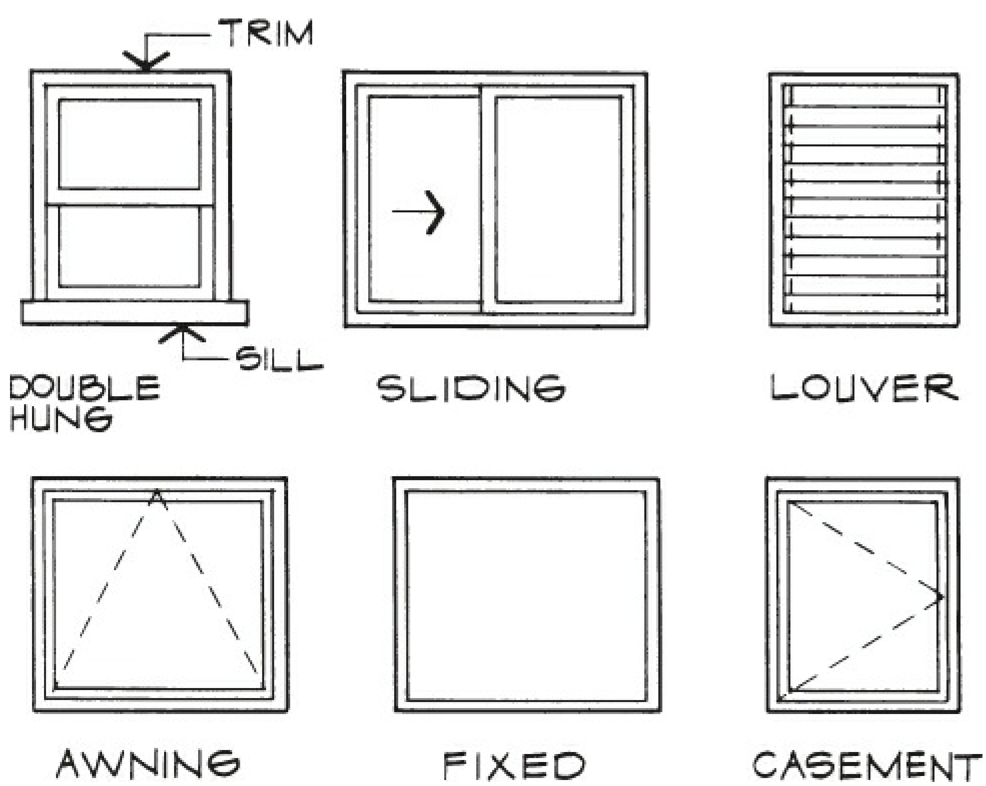


Figure 11.25 Windows in elevation.

On double‑hung and sliding windows, one portion of the window is shown in its entirety, whereas the moving section shows only three sides of the window. Using the sliding window in Figure 11.25 as an example, the right side of the window shows all four sides because it is on the outside. The left section shows only three sides, because the fourth side is behind the right section.

Fixed Windows. If the window is *fixed* (nonopening), as shown in Figure 11.26, you must know whether the window is to be shop made (manufactured ahead of time) or constructed on the job. If the frame can be ordered—in aluminum, for example—treat it like other manufactured windows and include it in the window schedule. If the window is to be job made (made on the site), provide all the necessary information about the window on the window schedule or exterior elevations, as shown in Figure 11.27. However, keep all this information in one place for consistency and uniformity.

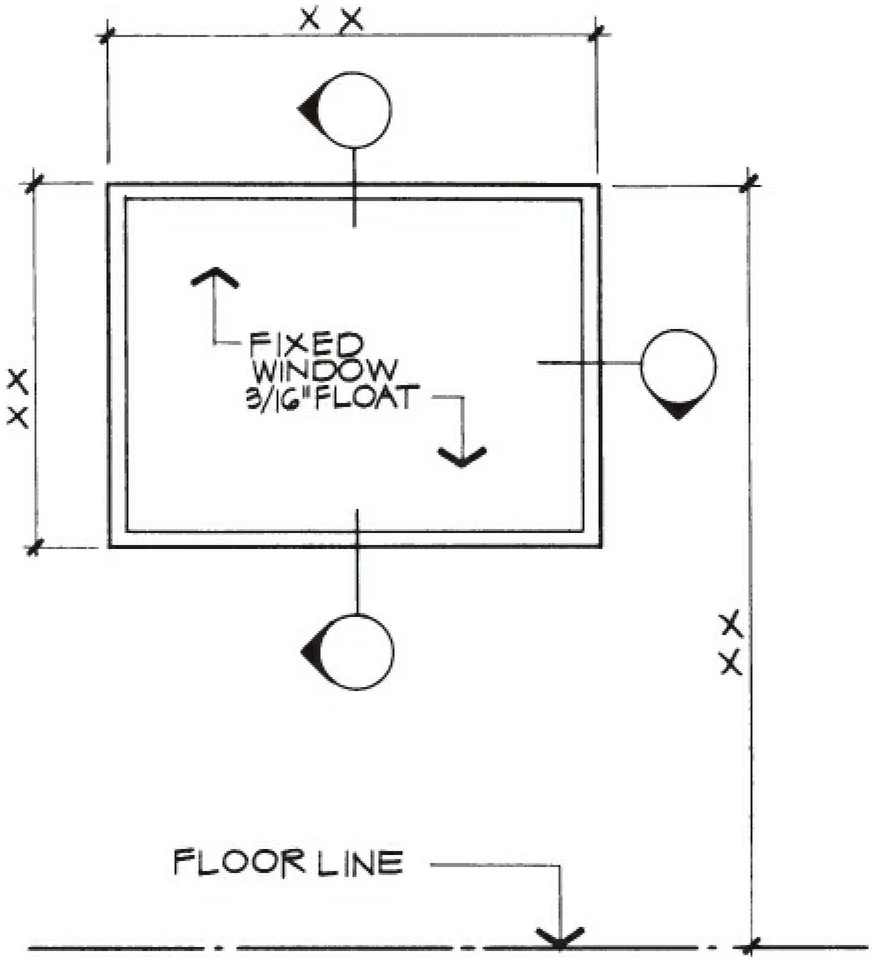


Figure 11.26 A fixed window.

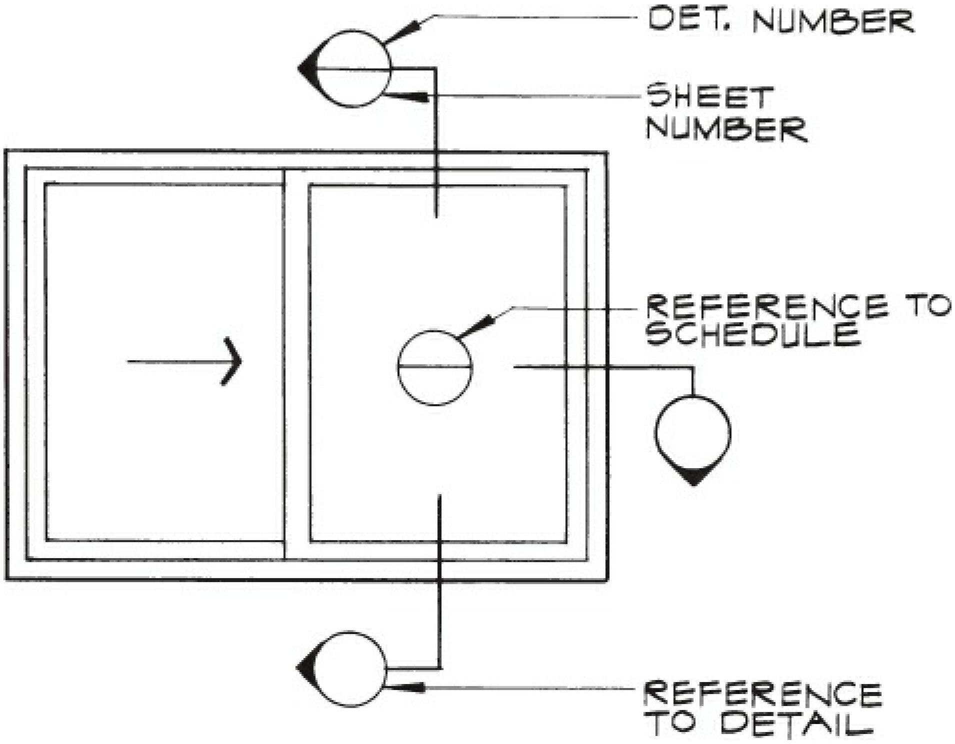


Figure 11.27 Wood window details.

Referencing Doors and Windows. Reference doors and windows with bubbles. Bubbles can refer to details or to a schedule for size. See Figure 11.27. If, for some reason, there are no schedules or details for a set of drawings, all information pertaining to the windows or doors will be on the exterior elevations near or on the windows and doors or on the floor plan at the door or window location. See Figure 11.26.

MATERIAL DESIGNATIONS

Describing the Materials

The exterior elevations also describe the exterior wall surface material. For a wood structure, describe both the surface covering and any backing material. *Wood siding*, for example, is described with the backing behind it. See Figure 11.28.

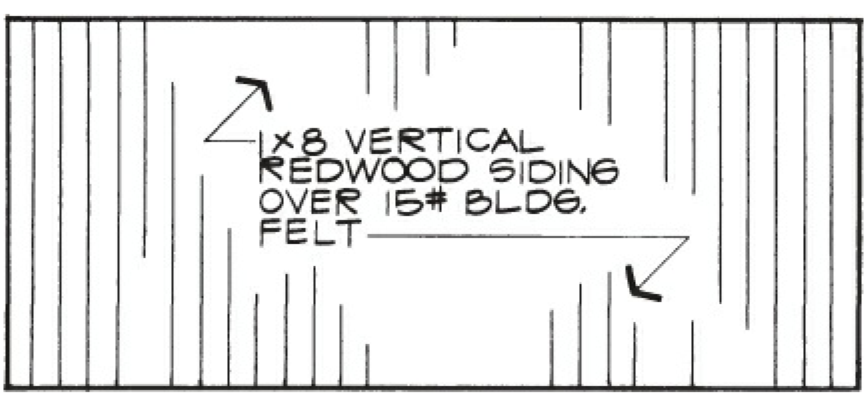


Figure 11.28 Wood siding in elevation.

In some cases, one word, such as *stucco,* describes the surface adequately unless a special pattern is to be applied. Here, the drafter assumes that the contractor understands that

the word *stucco* implies building paper (black waterproof paper), mesh (hexagonal woven wire), and three coats of exterior plaster. Often, a more detailed description of the material is found in the specifications. The “stucco” finish, for example, might be described as “20/30 steel trowel sand.”

Even if the complete wall is made up of one material, such as concrete block (as opposed to a built‐up system as in wood construction), describe the surface. See Figure 11.29.

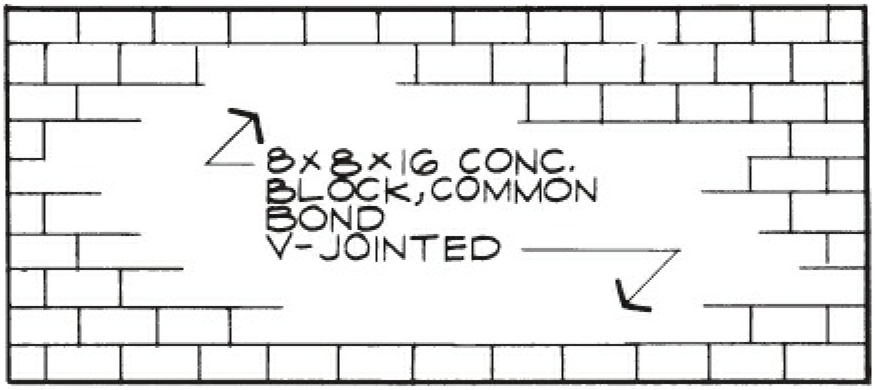


Figure 11.29 Concrete block in elevation.

Drawing the Materials

A facsimile of the material is shown in both Figures 11.28 and 11.29. The material representation does not fill the complete area but is shown in detail around the perimeter only, which saves production time. Figure 11.30 shows more of the area covered with the surface material, but in a slightly more abstract manner. Another method is to draft the surface accurately and erase areas for notes.

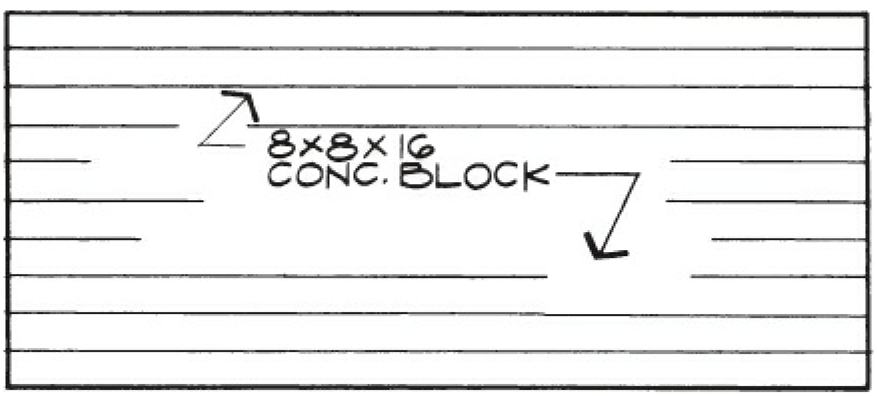


Figure 11.30 Abbreviated concrete‐block pattern.

Figure 11.31 shows other materials as they might appear in an exterior elevation. These are only suggestions. Scale and office practice dictate the final technique. See Figure 11.32.

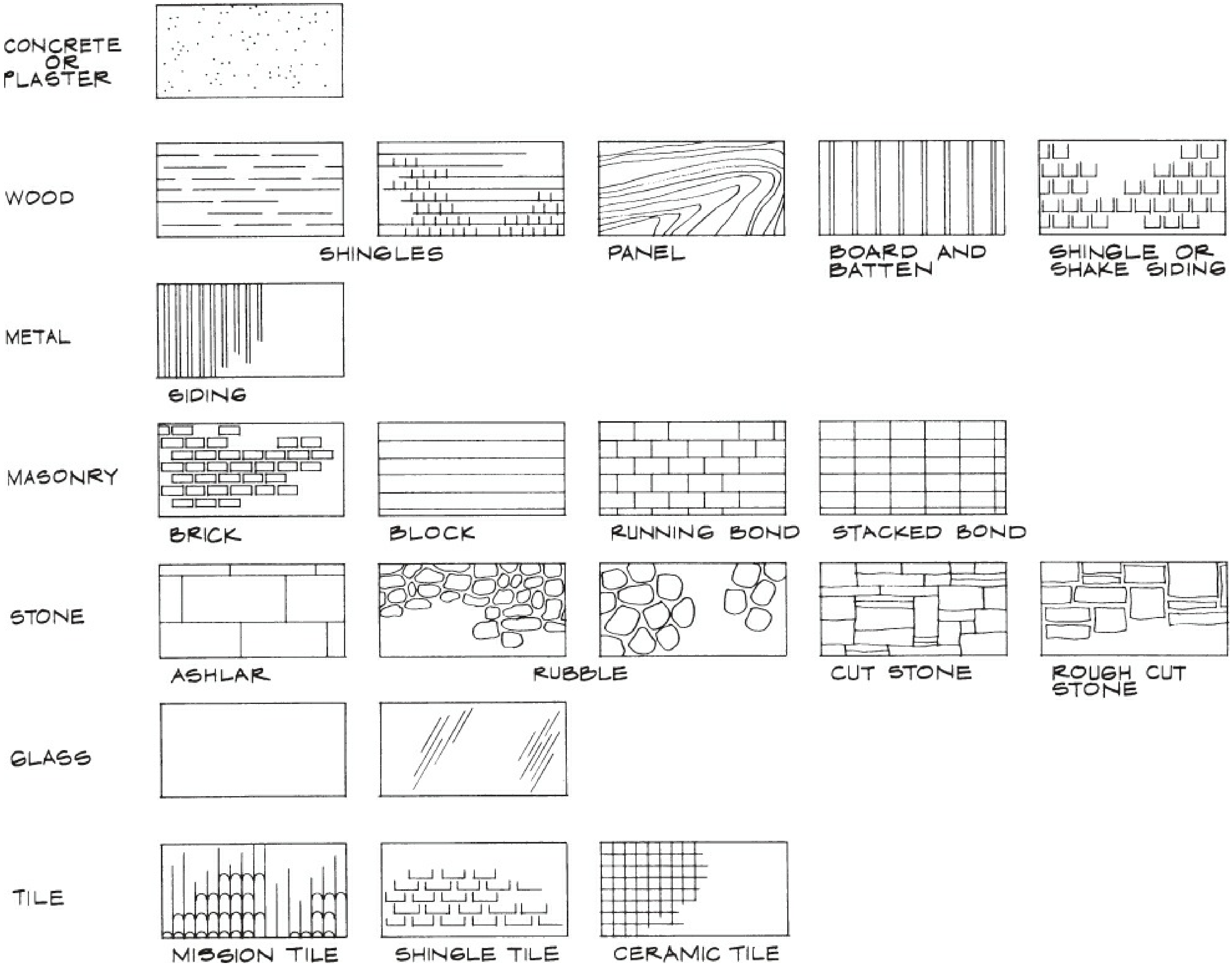


Figure 11.31 Material designations.

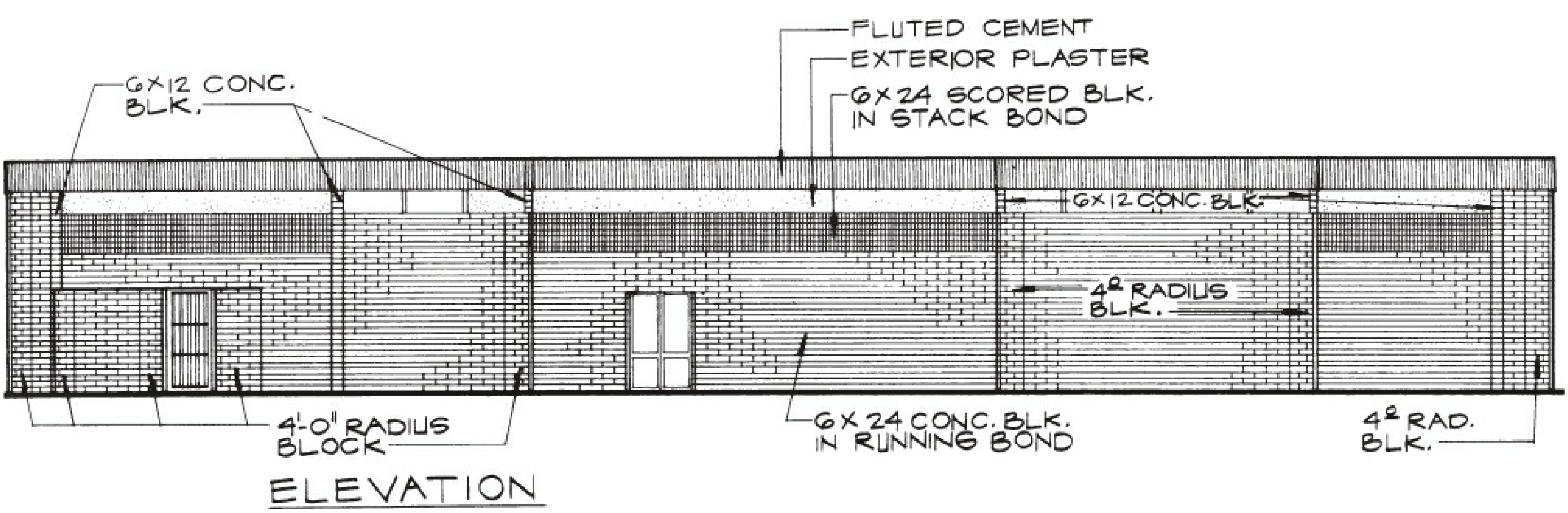


Figure 11.32 Masonry structure with variations in building patterns.

Eliminating Unnecessary Information

Because exterior elevations are vital in the construction document process, unnecessary information should be eliminated. Shades and shadows, cars, bushes and trees, people, and flowers add to the look of the drawings but serve no purpose here. These components are utilized for presentation elevations, client documents, city preliminary revisions, or landscape plans. If AutoCAD or Revit is used, layers can be voided to accomplish this.

Notes

Order of Notes. Notes on elevations follow the same rules as notes on other drawings. The size of the object is first, then the name of the material, and then any additional information about spacing, quantity, finish, or methods of installation. For example,

1 × 8 redwood siding, rough sawn over 15# (15 lb) building felt

or

Cement plaster over concrete block, smooth finish

or

Built…up composition gravel roof

or

1 × 6, let…in bracing

In the second example, no specific sizes are needed, so the generic name comes first in the note.

Noting Practices. Noting practices vary from job to job. A set of written specifications is often provided with the construction documents. Wall material on a set of elevations may be described in broad, generic terms, such as “concrete block,” when the specific size, finish, stacking procedure, and type of joint are covered in the specifications.

If there are differences between the construction documents and the specifications, the specifications have priority (the specs control). In the construction documents, often the same material note can be found more than once. If an error is made or a change is desired, many notes must be revised. In the specifications, where material notes are mentioned once, only a single change has to be made.

There are exceptions. When there are complicated changes and variations of material and patterns on an elevation, it is difficult to describe them in the specifications. In this case, the information should be located on the exterior elevations. See Figure 11.32.

Hidden Lines (Dotted Lines)

Doors and Windows. Hidden lines (dotted lines) are used on doors and windows to show how they operate. See illustration D of Figure 11.24 and the awning and casement windows in Figure 11.25. These dotted lines show which part of the door or window is

hinged. See Figure 11.33. Not all offices like to show this on an elevation. One reason is showing door swings using hidden lines has been a common practice to alert the craftsman on the job that the door does not interfere with any electrical fixture, columns, and so on. Some offices have selected not to show door swings on the elevations because the floor plan shows the door swing.

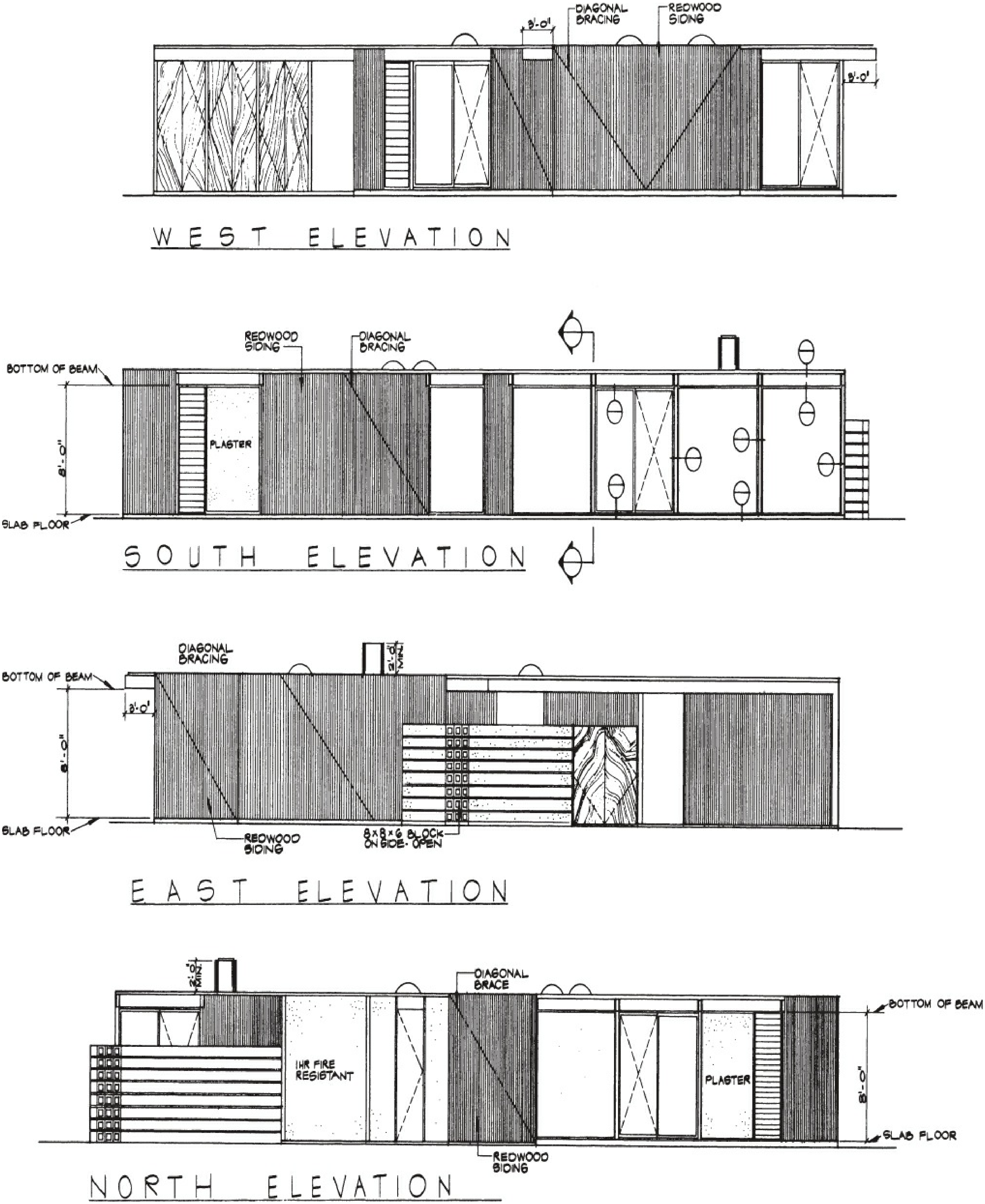
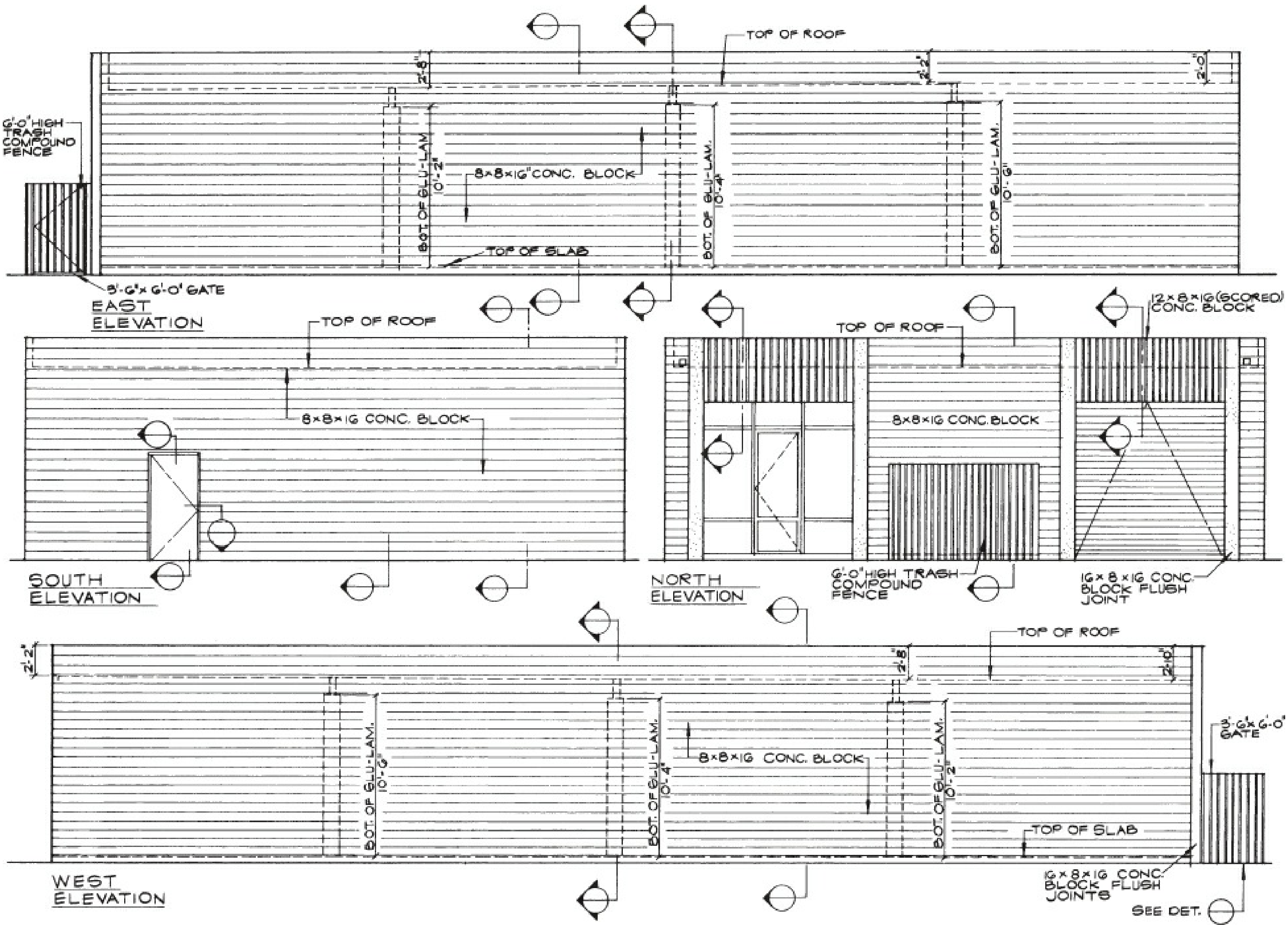


Figure 11.33 Elevation in wood.

Foundations. At times, you may have to delineate the foundation on the elevations in order to explain the foundation better. Dotted lines are used in various ways relating to the foundation. Dotted lines (centerline…type lines are also used) show the top of a slab, as in [Figure 11.34](). They are also used to show the elevation of the footings. See [Figure 11.35]() for elevations of a two…pour footing and a one…pour footing or to delineate a basement.



[Figure 11.34]() Elevation in masonry.

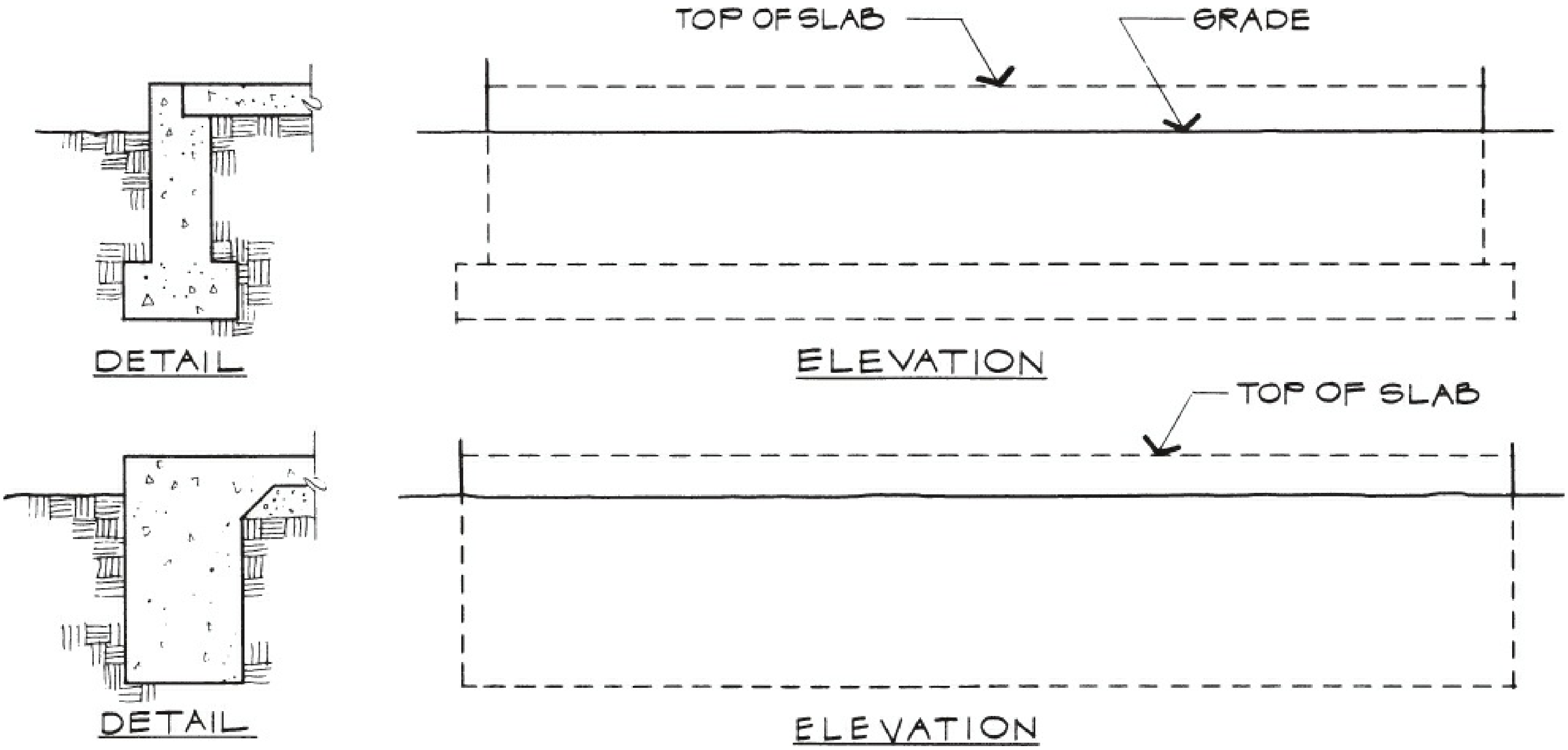


Figure 11.35 Showing the foundation on an elevation.

Dotted lines are also used to describe a **stepped footing**. When the property slopes, the minimum depth of the footing can be maintained by stepping the footing down the slope. See Figure 11.36.

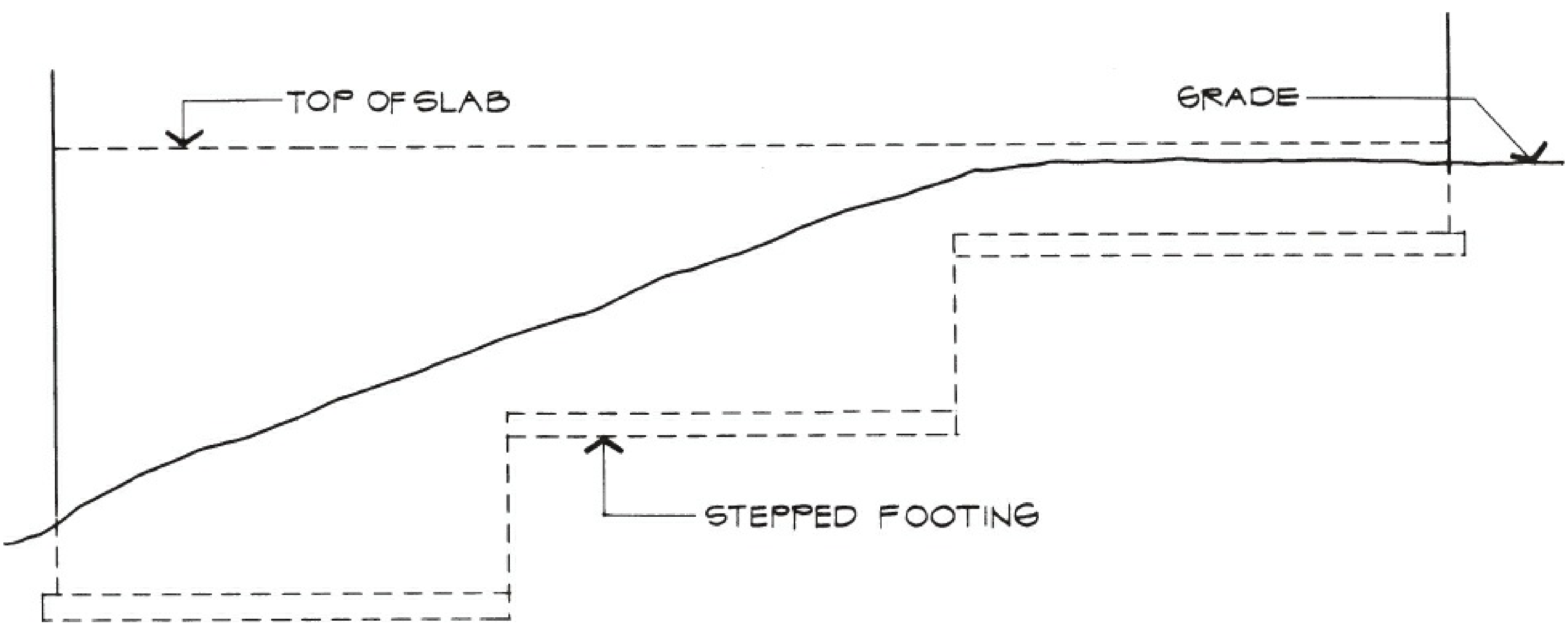


Figure 11.36 Stepped footings in elevation.

Structural Features. Structural features below the grade can be shown by dotted lines if this helps to explain the structure. See Figure 11.37. Dotted lines can also be used to help show structural elements of the building. In Figure 11.10, centerline‐type lines (which can also be used) show *let‐in braces* (structural angular braces in a wall). (The plate line is the top of the two horizontal members at the top of the wall, called *top plates*.) In Figure 11.34, dotted lines show the top of the roof, which slopes for drainage; a

pilaster (a widening of the wall for a beam); and a beam (a laminated beam) for window wells.

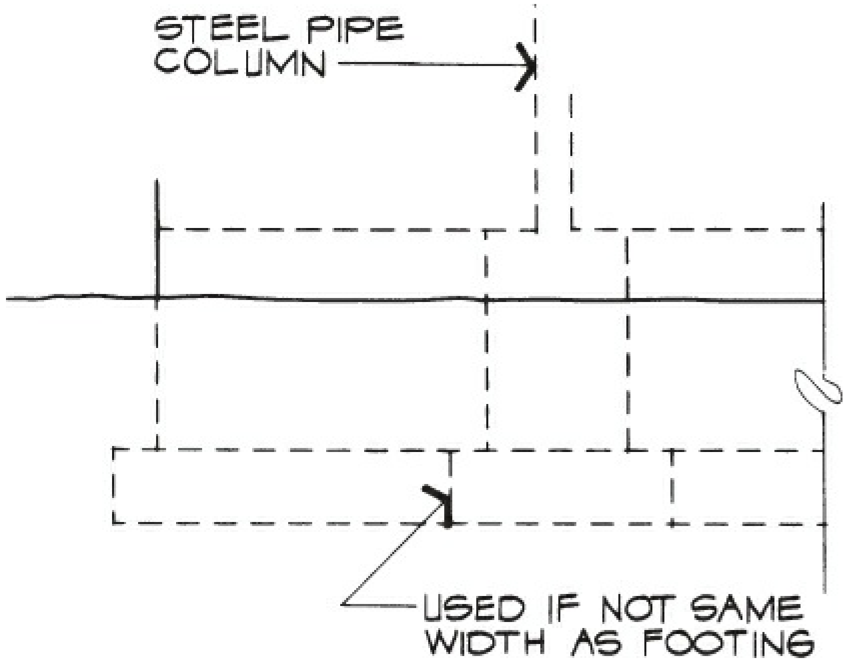


Figure 11.37 Structural features below grade.

As with doors and windows, the footing on an elevation can be referenced to the foundation plan, details, and cross…sections. The system is the same. Reference bubbles are used. See Figure 11.38.

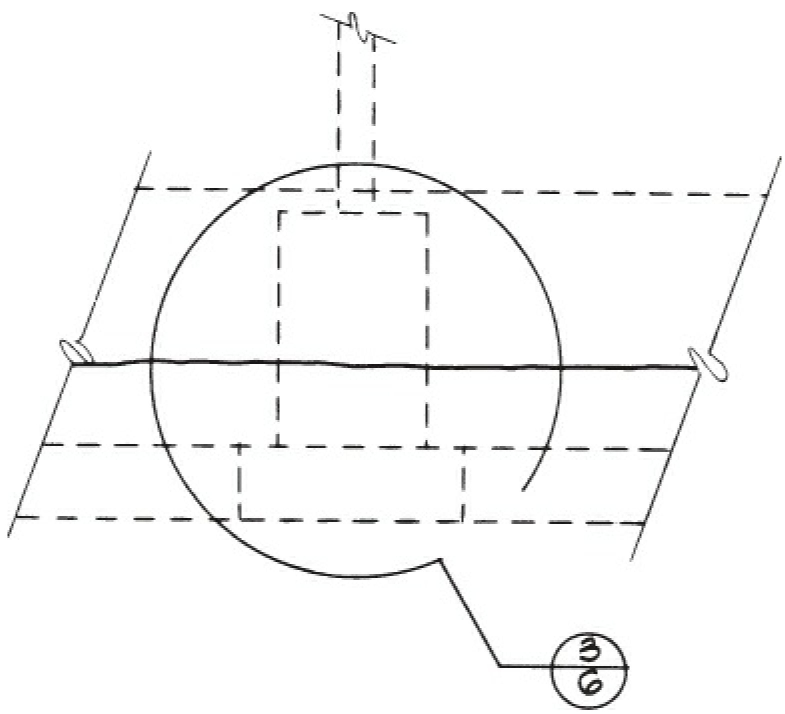


Figure 11.38 Referencing hidden lines.

Whatever the feature, the dotted line is used for clarity and communication. How can you keep the message clear for construction purposes? How can you best communicate this on the drawings?

Controlling Factors

Each type of construction has unique restrictive features that you need to know about to effectively interpret the transition from design elevations to production of exterior elevations in the construction documents.

Wood Frame Structures

With wood frame structures, elevations are usually dictated by plate line heights. The *plate height* is measured from the floor to the top of the two top plates. See Figure 11.8. Efficient use of material is dictated by this dimension because studs are available in certain lengths and sheathing usually comes in 4′ × 8′ sheets.

Floor, Plate, and Grade Lines. When the floor elevations and plate heights are established, the first thing to draw is the floor line and its relationship to the grade. Next, draw the plate line. If the structure is of post…and…beam construction, measure from the floor line to the bottom of the beam. Some offices prefer to put these dimensions on the building sections.

Find the distance between the floor line and the grade line from the grading plan, foundation plan, footing details, and building sections. If the lot is relatively flat, just draw a grade line with the floor line measured above it and the plate line height above the floor as a start. If the site is not flat, carefully plot the grade line from the grading plan, foundation plan, and details or the site plan.

Some site plans, grading plans, and foundation plans indicate the grade height, marked F.G. (finished grade), in relation to the structure at various points around the structure. In Figure 11.39, the grade line is figured by making a grid where the horizontal lines show grade heights and vertical lines are projected down from the structure. Once this grade line is established, the top of the slab—that is, the floor line—is drawn. The plate line is then measured from the floor line. There is no need to measure the distance between the grade and the floor line. See Figure 11.40.

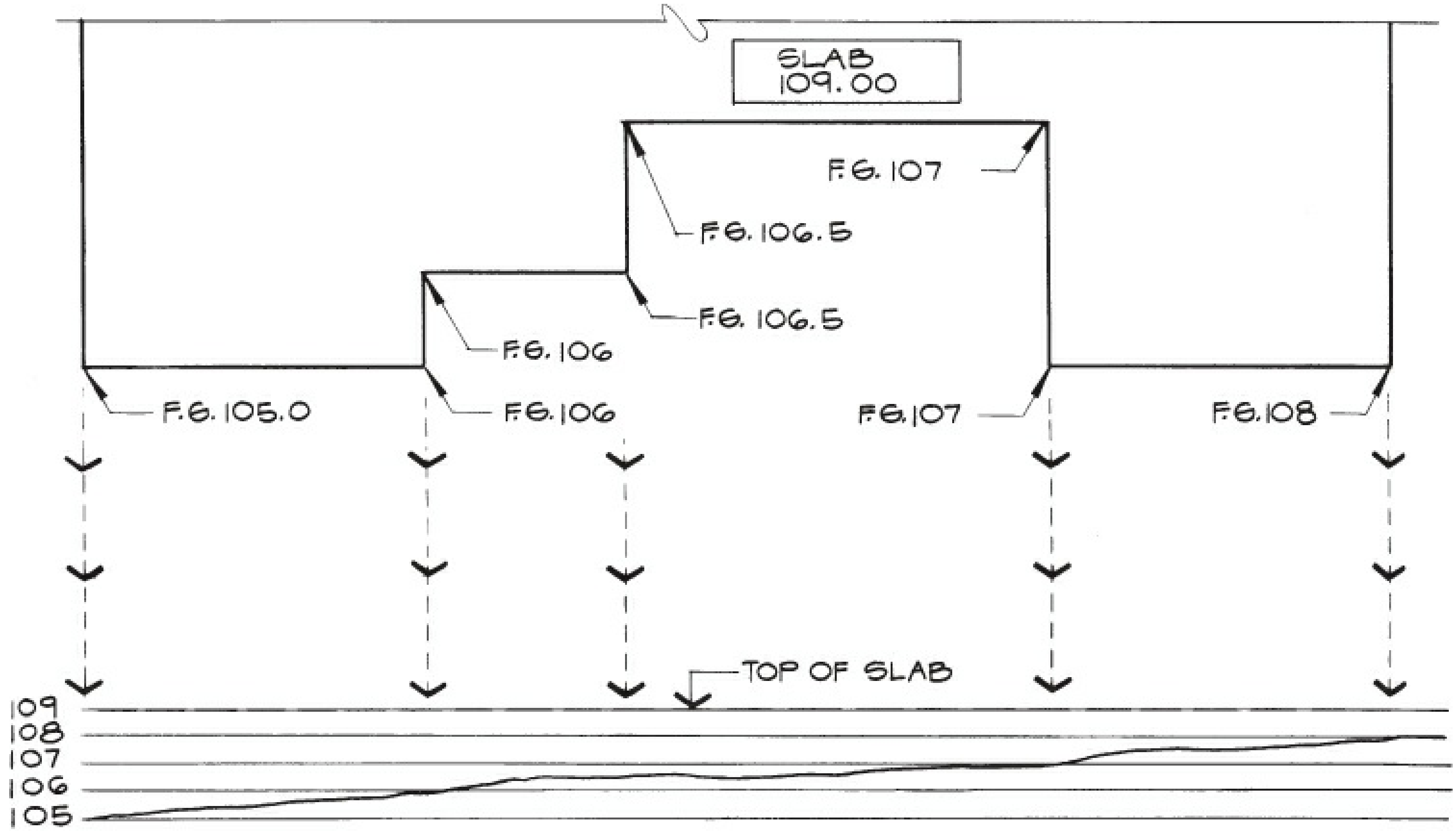


Figure 11.39 Plotting grade lines for an elevation.

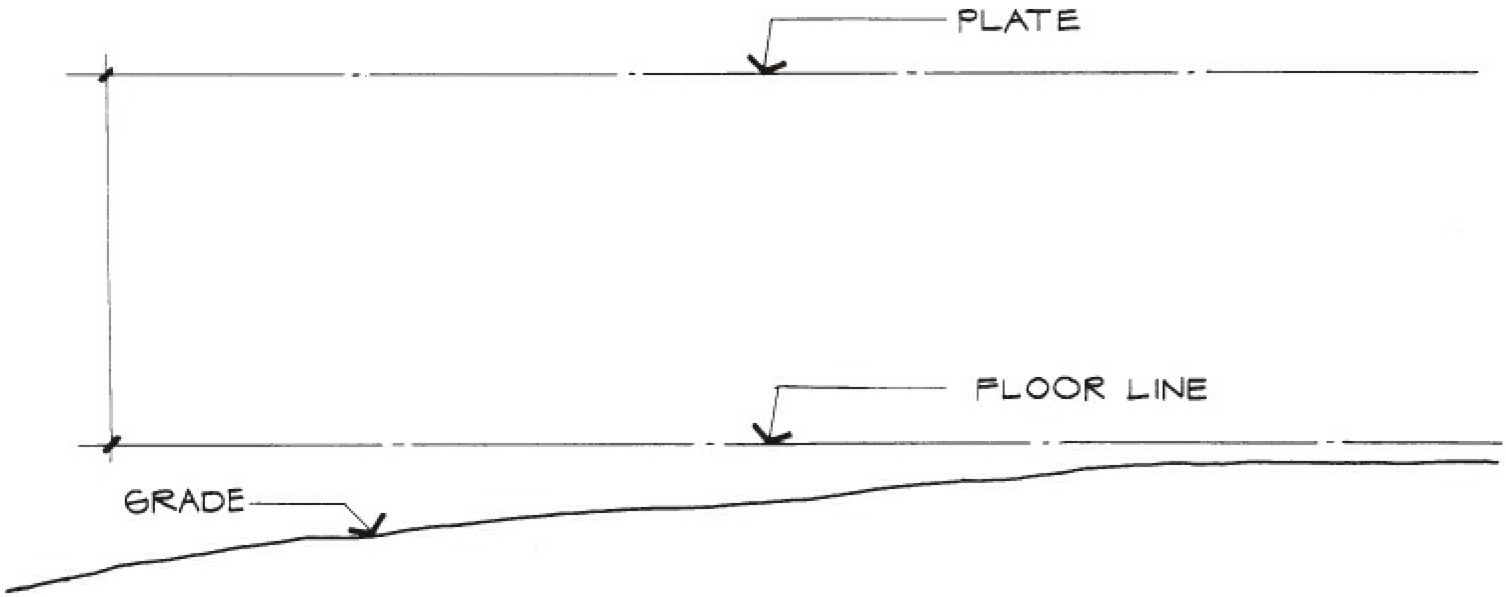


Figure 11.40 Preliminary steps for drafting an elevation with grade variation.

Masonry Structures

Masonry structures, such as those of brick or concrete masonry units (CMU), must be approached differently. The deciding factor here is the size of the concrete block or brick, the pattern, the thickness of the joint, and the placement of the first row in relationship to the floor. Unlike wood, which can be cut in varying heights, masonry units are difficult to cut, so cutting is minimized. As Figure 11.32 shows, dimensions of the masonry areas are kept to a minimum. In a wood frame structure, the lumber can be cut to size on the job. In masonry, the size of the masonry units often dictates such things as the location of

windows and doors, the modular height, and so on. Some of the controlling factors in steel construction are: the size of the structural members; the required ceiling heights; and the *plenum* area (the space necessary to accommodate the mechanical equipment and ductwork). See Figure 11.41. Refer to the discussion of noting, earlier in this chapter, for suggested practices and sample illustrations.

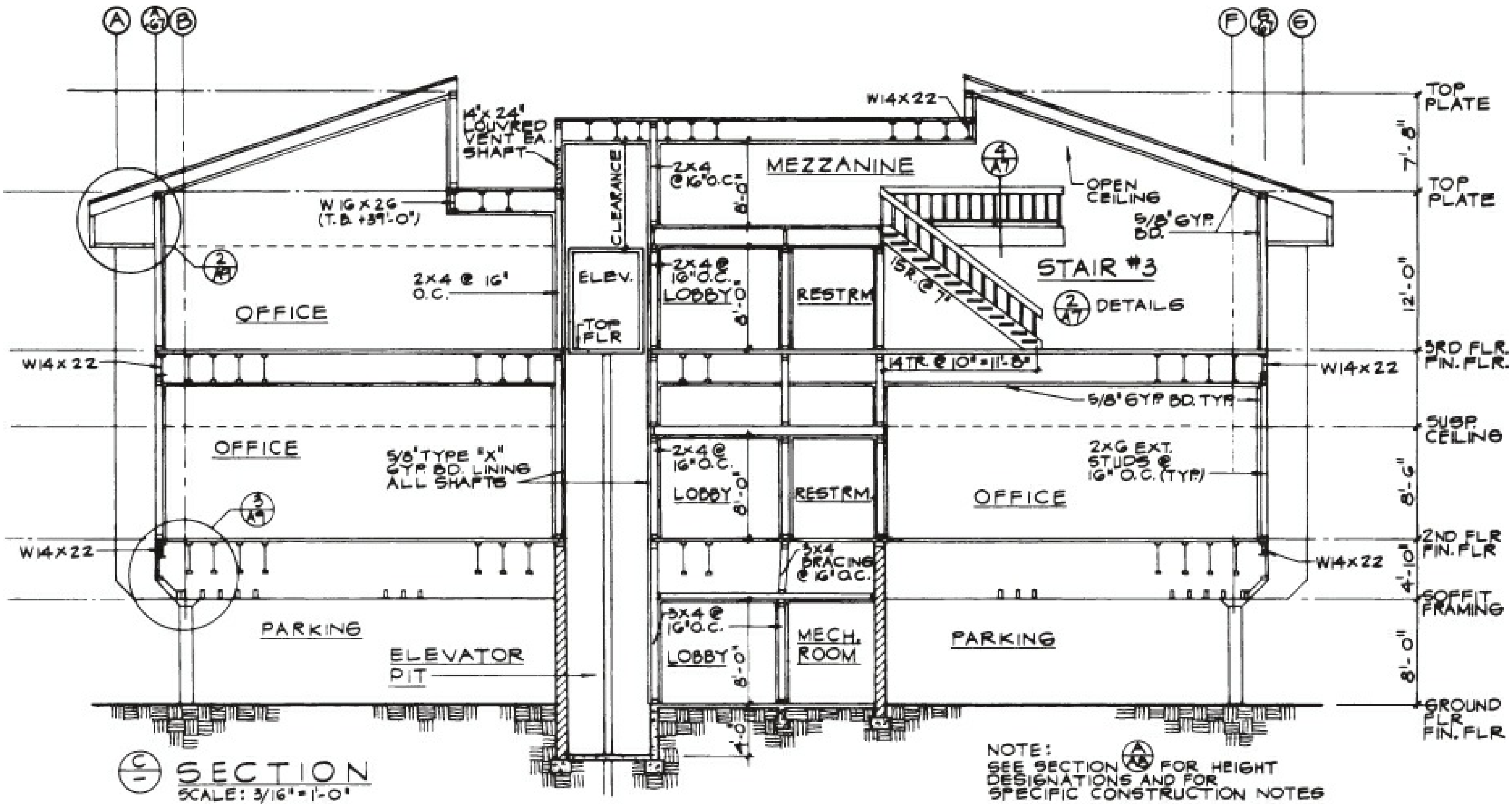


Figure 11.41 Section of a steel and wood structure.

(Courtesy of Westmount, Inc., Real Estate Development.)

Steel Structures

Structures in which the main members are steel and the secondary members are, for example, wood are treated differently from wood structures or masonry. The configuration is arrived at in the same way and representation of material is the same, but dimensioning is completely different.

Drawing an exterior elevation for a steel structure is a relatively simple task. Usually, the floor elevations on a multistory structure of steel are established by the architect. The building section usually provides the necessary height requirements. See Figure 11.41. Figure 11.42 is a checklist for exterior elevations.

EXTERIOR ELEVATIONS CHECKLIST

1. Natural grade
2. Finish grade
3. Floor elevations
4. Foundation (hidden lines)
   a. Bottom of footing
   b. Top of foundation (stepped footing)
   c. Detail reference
5. Walls
   a. Material
      (1) Wood
      (2) Stucco
      (3) Aluminum
      (4) Other
   b. Solid sheathing
      (1) Plywood
      (2) 1 × 6 diagonal
      (3) Other
   c. Diagonal bracing (hidden lines)
6. Openings
   a. Heights
      (1) Door and window min. 6' - 8"
      (2) Post and beam special
   b. Doors
      (1) Type
      (2) Material
      (3) Glass
      (4) Detail reference
      (5) Key to schedule
   c. Windows
      (1) Type
      (2) Material
      (3) Glass—obscure for baths
      (4) Detail reference
      (5) Key to schedule
   d. Moulding, casing and sill
   e. Flashing (gauge used)
7. Roof
   a. Materials
      (1) Built-up composition, gravel
      (2) Asphalt shingles
      (3) Wood shingles or shake
      (4) Metal-terne-aluminum
      (5) Clay and ceramic tile
      (6) Concrete
   b. Other
8. Ground slopage
9. Attic and subfloor vents
10. Vertical dimensions
11. Window, door fascia, etc. detail references
12. Roof slope ratio
13. Railings, note height
14. Stairs
15. Note all wall materials
16. Types of fixed glass and thickness
17. Window and door swing indications
18. Window and door heights from floor
19. Gutters and downspouts
20. Overflow scuppers
21. Mail slot
22. Stepped foundation footings—if occur
23. Dimension chimney above roof

Figure 11.42 Exterior elevations checklist.

DRAFTING AN EXTERIOR ELEVATION

Drawing an exterior elevation is a straightforward procedure, because most of the structural and shape descriptions have been completed by the time it is drafted: The shape of the roof, the size of the site component parts, the shape and size of the foundation, and all of the vertical heights were determined when drafting the building section. For a small structure, such as those contained in this book, we believe it is the easiest drawing to accomplish.

Guide to Dimensioning

Do not dimension anything on the exterior elevation that has been dimensioned elsewhere, unless you are using Revit. For example, the distance between the floor line and the plate line is dimensioned on the building section and should not be repeated on the exterior elevation. In contrast, windows have been described (width and height) on the schedule, yet their positions in relation to the floor line have not. This makes the exterior elevation an ideal place to dimension these positions, as well as such architectural features as signage on a commercial building.

Descriptions

Anything that can be described better by drawing should be drawn, and anything that would be better as a written description should be included in the specifications. Noting should use generic terms. It would be sufficient to label the exterior covering (called *skin*) “redwood siding” or “stucco” (exterior plaster), rather than describing the quality of the siding or the number of coats and quality of the stucco.

Concerns

Compare the exterior elevation to the human body. In both instances, the outside cover is called the *skin*. Directly below the skin is the muscle. The muscle might be comparable to the substructure that strengthens a structure, such as metal straps, let…in braces, and shear panels. See Figure 11.43. The purpose of these members is to resist outside forces, such as wind, hurricanes, and earthquakes. The skeleton within a human body is analogous to the “bone structure” of a building, which is in the form of a network of wood pieces called *studs*.

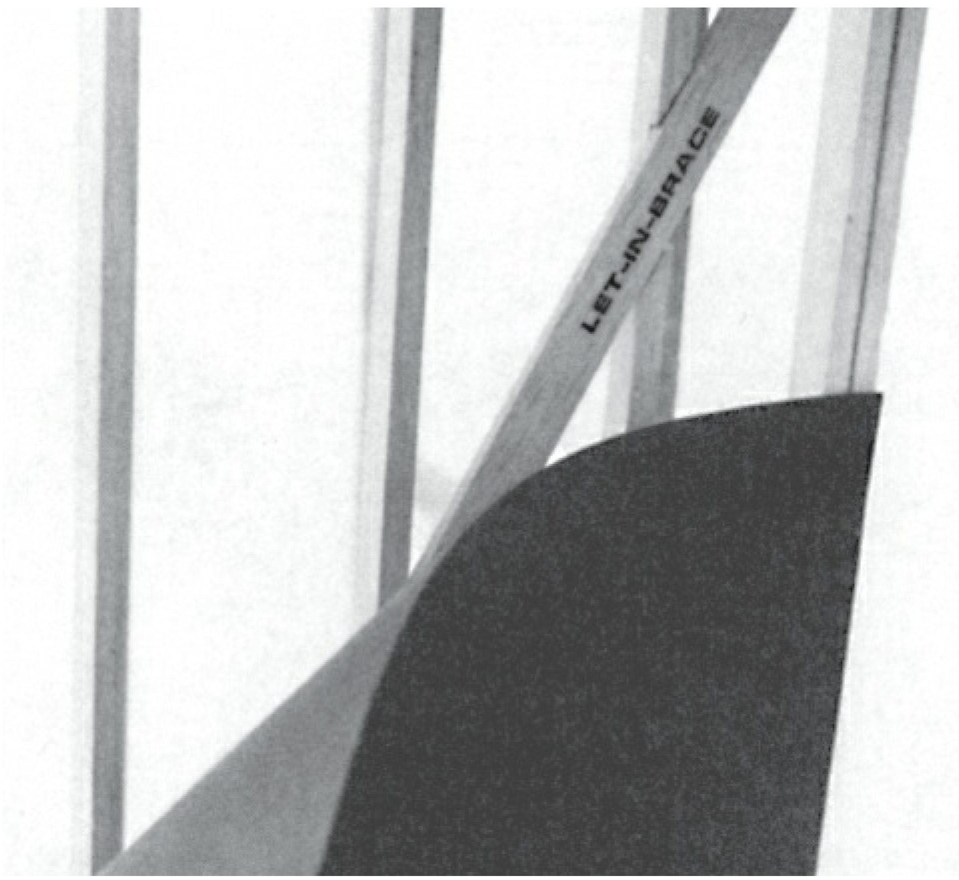


Figure 11.43 Revealing let…in brace.

The exterior elevation addresses the “skin and muscle,” and the building section emphasizes the skeletal form.

Use of Hidden Lines

Hidden lines are used on an exterior elevation to reveal structural members behind the surface. See Figure 11.34. Notice, in this figure, the use of hidden lines to show the slope

of the roof, the pilaster, the hinged side of doors and windows; in Figure 11.33, hidden lines are used to show diagonal bracing.

Now look at Figure 11.44. The outline of a gable roof (roof plan) is translated into elevations. Notice that in the front view the small bend in the roof at the top right corner does not show, whereas in the rear view the entire shape is shown and the right‐side view shows only a single roof but nothing behind it. Hidden roof lines are not shown.

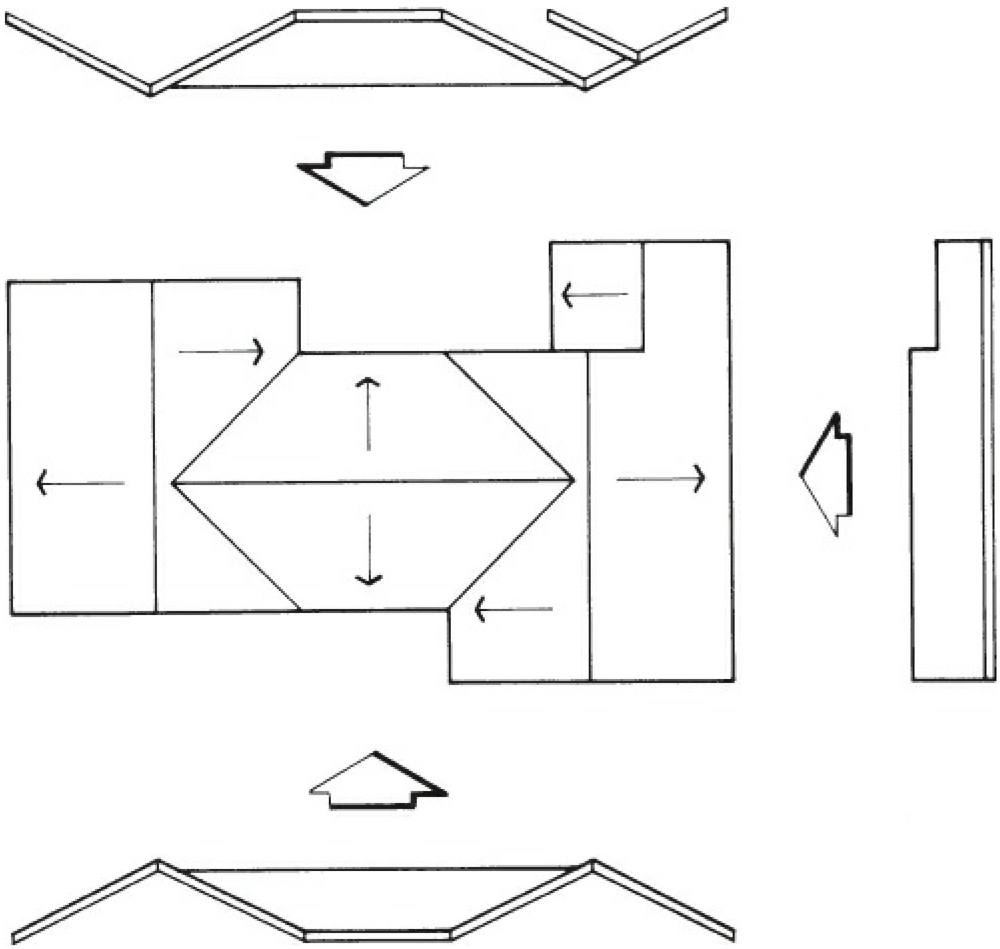


Figure 11.44 Visualizing roof in elevation.

Pictorial versus Written Description

It often takes a combination of a drawing and a generic description to describe a material used for covering the outer surface of a structure. For example, a series of horizontal lines is used to describe siding, a row of masonry units, or possibly a texture pattern on exterior plaster.

WEATHERPROOFING

Weatherproofing a structure basically means keeping out wind, rain, and ultraviolet rays (UVRs) of the sun. UVR reduction is necessary because these rays are harmful to human skin and will fade the color of drapery, furniture, and carpets. In a residence, the solution is rather simple. Large overhangs on roofs can eliminate these harmful rays, as can the newly developed high‐performance glass used in windows.

Windows and doors are now made, or can be retrofitted, with weatherstripping. This keeps the structure energy efficient and prevents dust from entering the structure as a result of driving winds.

As you may have learned in a science course, the structure of water is different in its various phases: solid, liquid, and vapor. Therefore, a variety of materials are used to combat the migration of moisture from the outside to the inside of structures.

Generally, a cover is placed over the structure (especially the walls), much like a raincoat on a human. Yet, depending on the material of the raincoat, the wearer's body heat, the temperature of the air, and especially the humidity (moisture in the air), the inside surface of the raincoat will react differently. So it is with buildings. Buildings do perspire. Consider the following scenario: Driven by wind, moisture migrates from the outside to the inside of a structure in the form of vapor. This moisture changes its state through condensation because of temperature change and is unable to leave the inside of the wall. As night approaches, the temperature drops drastically, and the moisture now expands as it becomes a solid (ice). If this moisture happens to be inside the wood or insulation within the wall, it can cause terrible deterioration and damage. Had a vapor barrier been used, moisture might come from the inside of the structure and condense along this membrane as it tried to escape.

Solution to Condensation

A solution to condensation in the attic and under…floor space in a wood floor system can easily be achieved by proper ventilation and recirculation of the air. This is done with small openings through which venting can take place, using the wind as an ally, or the air can be recirculated mechanically, as is often done for bathroom ventilation.

Figure 11.45 is a map of the United States. Notice how it is divided into three major zones. Zone A experiences severe damage to structures as a result of condensation. Zone B experiences moderate damage, whereas the damage in Zone C is slight to almost none. This does not mean that there will never be moderate…to…severe damage in mountainous areas in Zone C; rather, this is a more generalized look at large geographic areas. Therefore, the drafter must be aware that a building in Southern California will *not* be dealt with in the same way as a building in the Dakotas, nor can a building in southern Texas be treated the same as one in Colorado.

Figure 11.45 U.S. condensation hazard zones.

Waterproofing

Waterproofing can be achieved in four ways:

1. The use of admixtures that render concrete impermeable.
2. Hydrolytically, by applying a waterproofing coat of asphalt or plastic to a surface.
3. Chemically, by applying a specially formulated paint to a basically porous surface such as concrete. Upon contact with water, this chemical crystallizes, sealing the pores. Such products are used more often for a retro‐fix than initial construction.
4. The use of a membrane. Older houses used ***bituminous‐saturated felts*** (also called *building felts*), which have recently been replaced with asphalt‐saturated kraft paper.

For a structure in Zone A, you may wish to select a material that will keep the colder side of the wall wind resistant and airtight and require that the material be a vapor retardant. On the warm side of the wall, you might wish to stop the migration of moisture into the wall by using a foil‐backed lath product. There are a number of products on the market today that can be specified by the project architect, including a vapor‐proof membrane, a membrane that can breathe, and a self‐sealing membrane for ice and water, as shown in Figure 11.46.

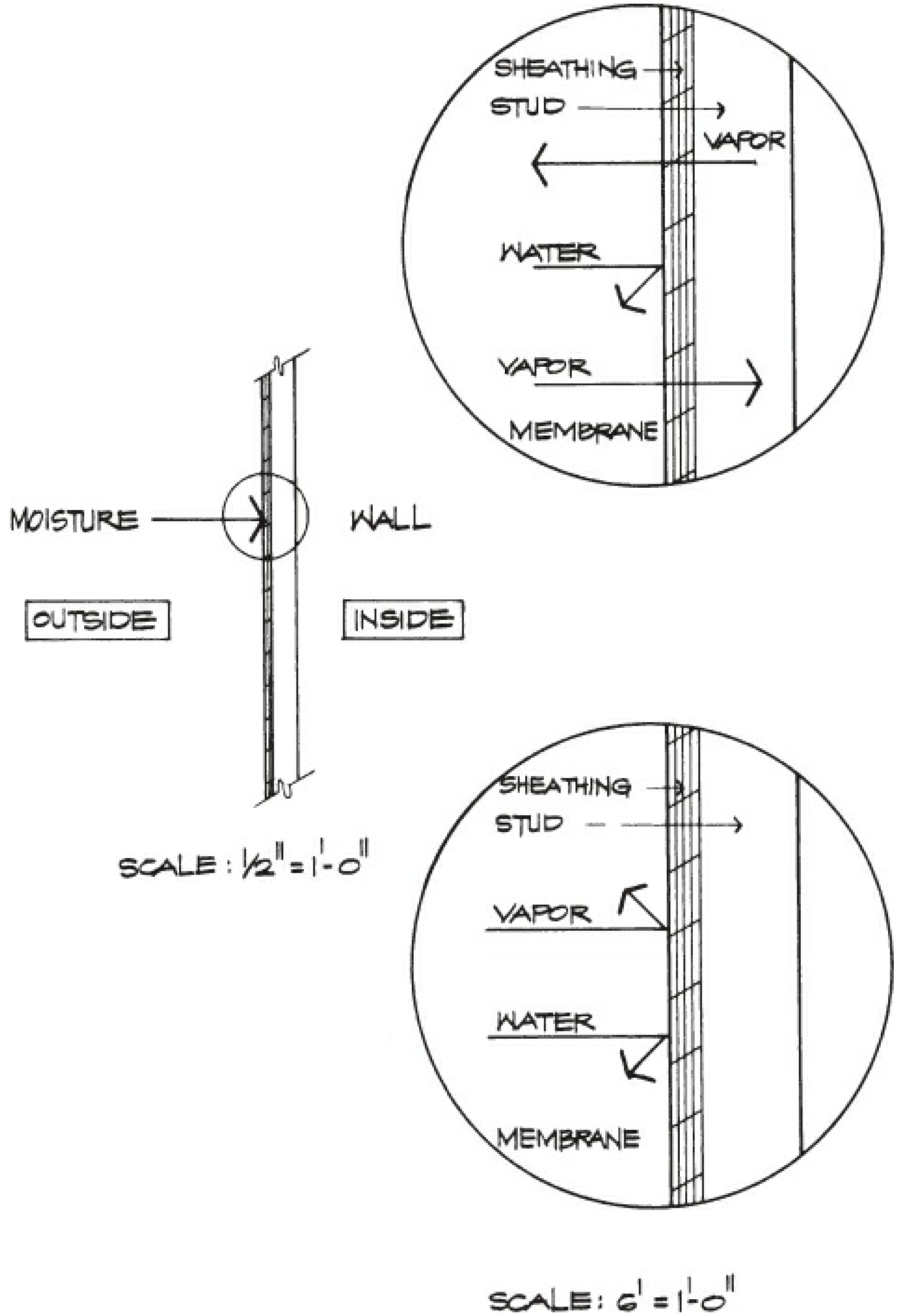


Figure 11.46 Breathing membranes and vapor membranes.

A drafter must know what is being used to properly ensure that he or she uses the correct convention and notation for drawings and details.

Counterflashing

Anytime you break the surface of a waterproof membrane, whether it is plastic or paper, a second sheet (usually of heavier weight) is used. This sheet, called ***counterflashing***, is found around openings and at the ends of the membrane, inasmuch as these are the places most likely to leak. In Zone C, for example, where asphalt…saturated (grade D) kraft paper is often used, a heavier…grade band of kraft paper, called *sisal…kraft*, is used. In other instances, a strip of self…sealing vapor membrane may be used around the opening. In either case, it should be done carefully so as to shed water lapping and

overlapping so as to let gravity take its natural course and help eliminate moisture.

Referencing

Referencing is the process of referring a specific area to an enlarged detail. Thus, the top half of the reference bubble indicates the name of the detail, and the bottom number indicates the sheet on which the particular detail can be found. On a complete set with details of all conditions, you would see detail reference bubbles around all windows, doors, beam connections, and so on.

Noting

Whenever possible, noting is done outside the elevation within the right margin. You cannot fit all of the notes in one place without having to use long leaders pointing to the subject. Therefore, certain notes are made inside the elevation to reduce the length of the leaders. A good rule of thumb in regard to leaders is not to allow them to cross more than one object line, never cross a dimension line, and keep the leader length to a minimum.

Many offices use *keynoting,* a procedure of numbering and placing all of the notes on one side (usually the right). You then place a leader in the desired location and, rather than placing the note at the end of the leader, you use a reference bubble that refers to the correct note.

The advantage of keynoting is the standardization of the notes. Keynoting also allows the drafter to make direct references to the specification numbers right on the notes. Numbering systems recommended by the American Institute of Architects are similar to the numbering system used by libraries and can be incorporated here.

DRAWING AN ELEVATION WITH AND WITHOUT A MODEL

With a 3…D model, the drafter needs only to rotate the image into an ortho mode and flatten it to create a base form for the elevation.

If a 3…D model is unavailable, the CAD drafter should use the base layer of the building section for the geometry layer under the base layer (datum layer) for the elevation.

Because we are drawing the structure full…scale, the drawings will transfer directly. If the drawings are prepared in paper space and/or the scale of the building section and elevation are to be drawn differently, the first stage of the building section must be changed in scale to suit the elevation.

Stage I The next move is to import the floor plan and position the walls as shown in Figure 11.47. The floor plan is temporarily positioned above the datum elevation drawing and rotated for each of the respective north, south, east, and west elevations. This drawing constitutes the base or datum stage of a set of elevations.

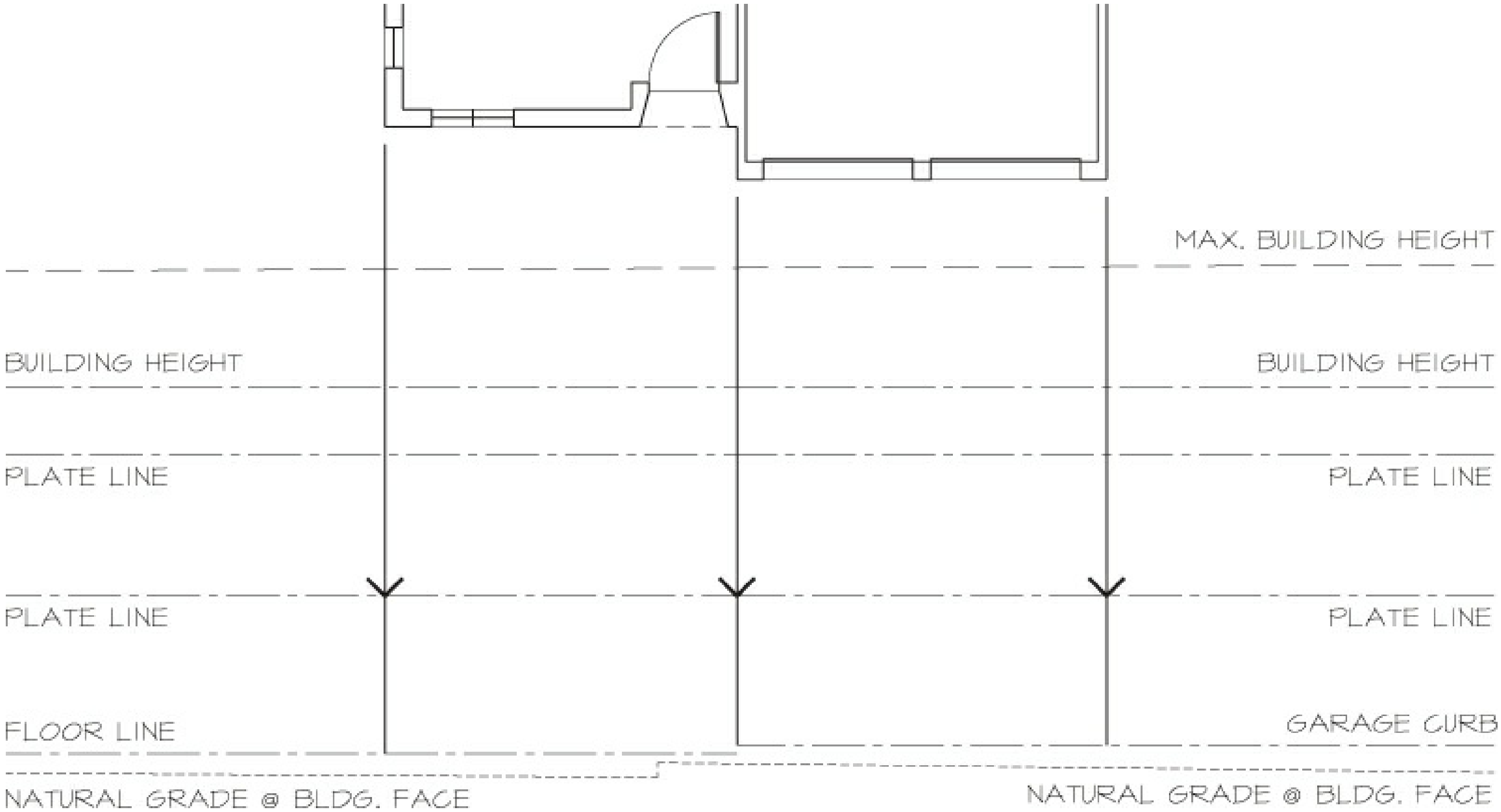


Figure 11.47 Stage I: Establishing a base (datum).

Stage II (Figure 11.48). The total outline of the structure is accomplished in this stage. The geometry of the roof and additional floor lines and plate lines are also incorporated as they change throughout the structure.

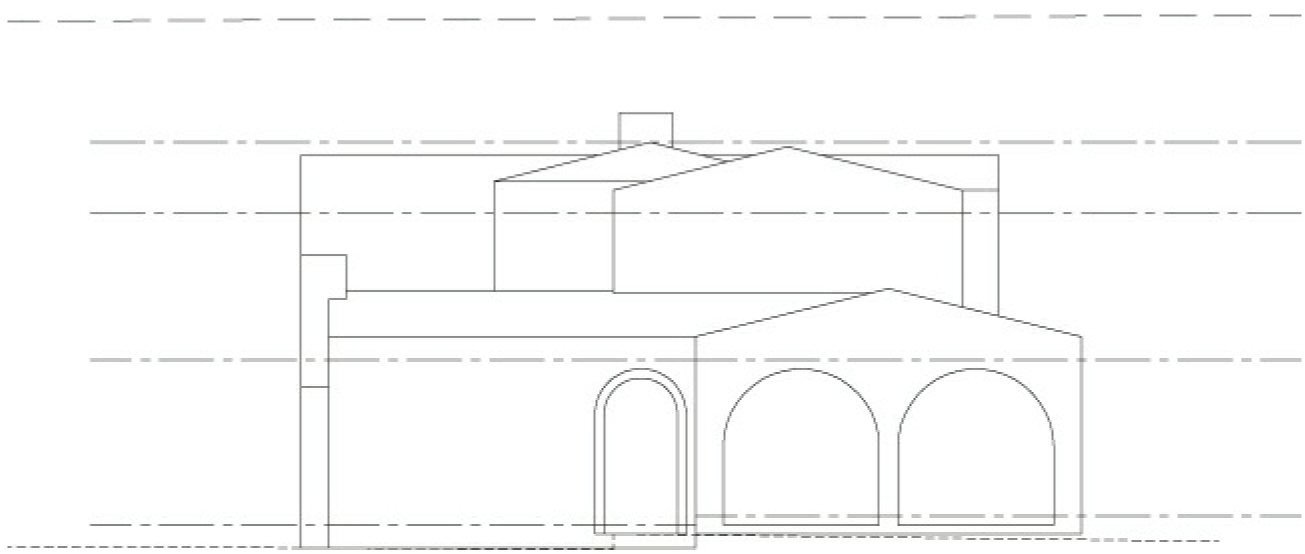


Figure 11.48 Stage II: Outline of structure.

Stage III (Figure 11.49). Doors and windows are positioned. It is best to get digital images from the manufacturer, and then size and position them. If the structure is subject to lateral loads, shear walls may be included at this stage, as would stepped footing or any other structural components.

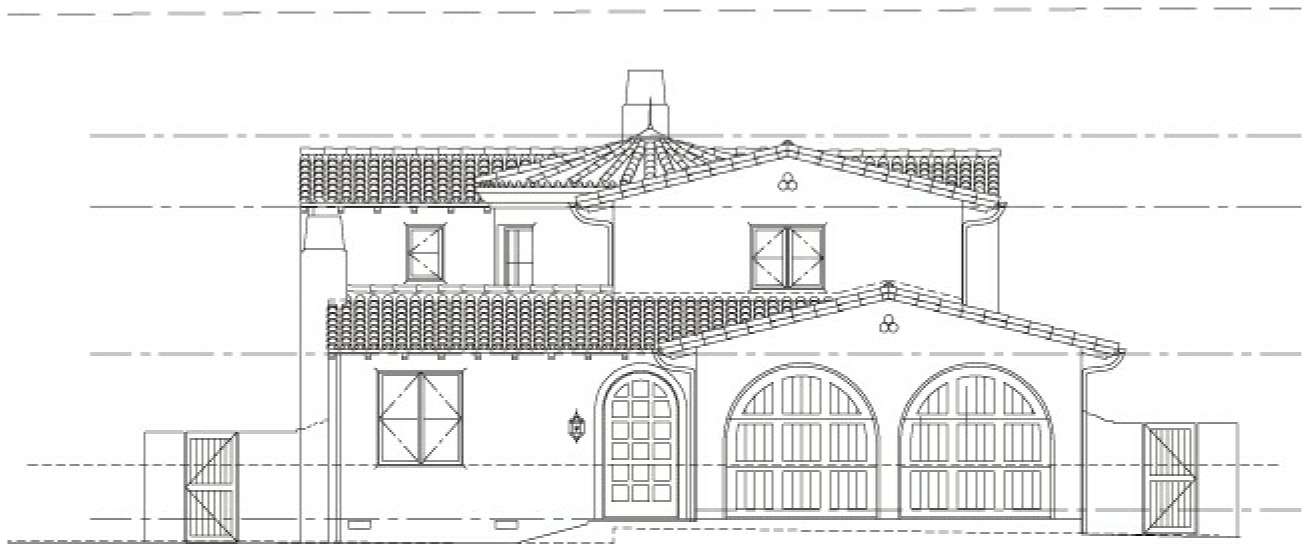


Figure 11.49 Stage III: Positioning doors, windows, and the like.

Stage IV (Figure 11.50). Line weight should be adjusted at this stage while adding texture. Adding texture may be fun, but restraint is recommended, so as not to disturb any notes or dimensions.

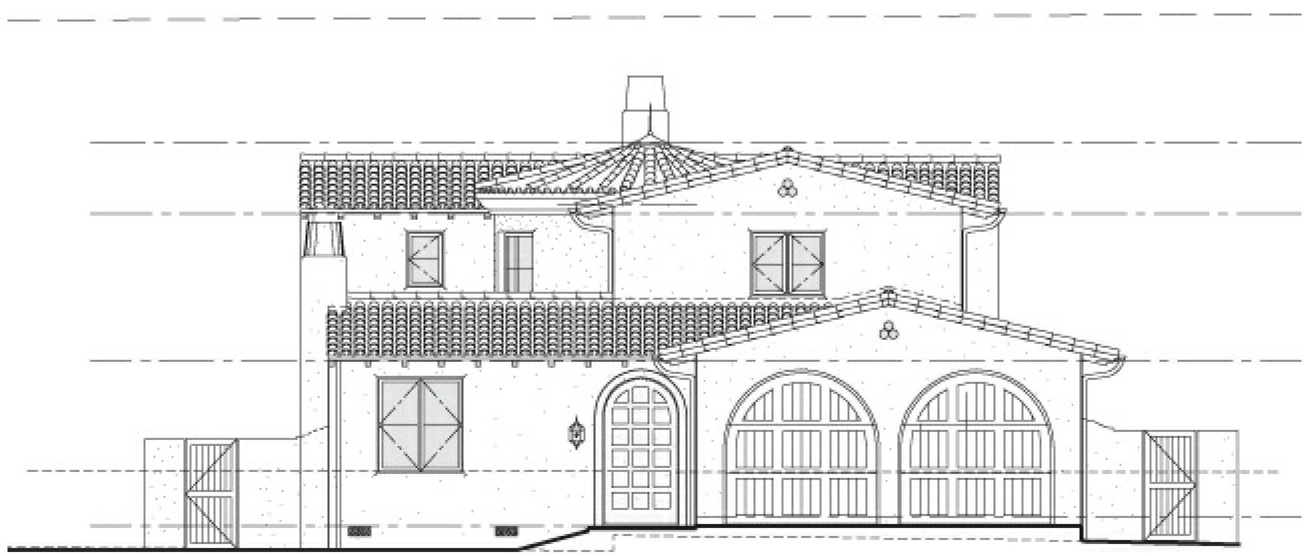


Figure 11.50 Stage IV: Adding texture and adjusting line quality.

Stage V (Figure 11.51). This is the dimensioning stage. Remember, the dimension for floor line to plate line should be noted once on the building section and should not be repeated here. Simply refer the floor…to…plate…line dimension to the section. Only those vertical dimensions that do not appear on the building section should appear here. Header height, ridge heights, handrail and guardrail dimensions, and heights of fences and walls adjacent to the structure are examples of actual dimensions that will appear on the exterior elevation.

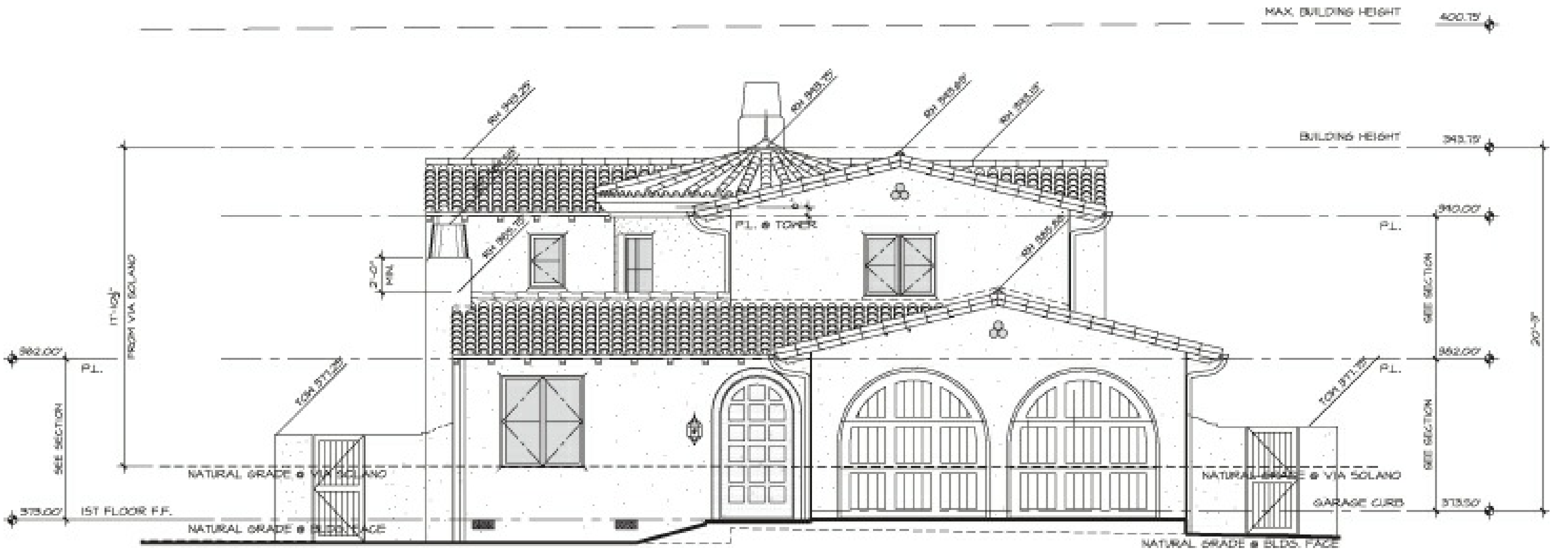


Figure 11.51 Stage V: Dimensioning stairs, handrails, and similar elements.

Stage VI (Figure 11.52). This is the noting, titling, and referencing stage, as well as final stage of the exterior elevations. Notes should be generic; only the specifications should cite the precise quantity, brand names, model numbers, and so forth.

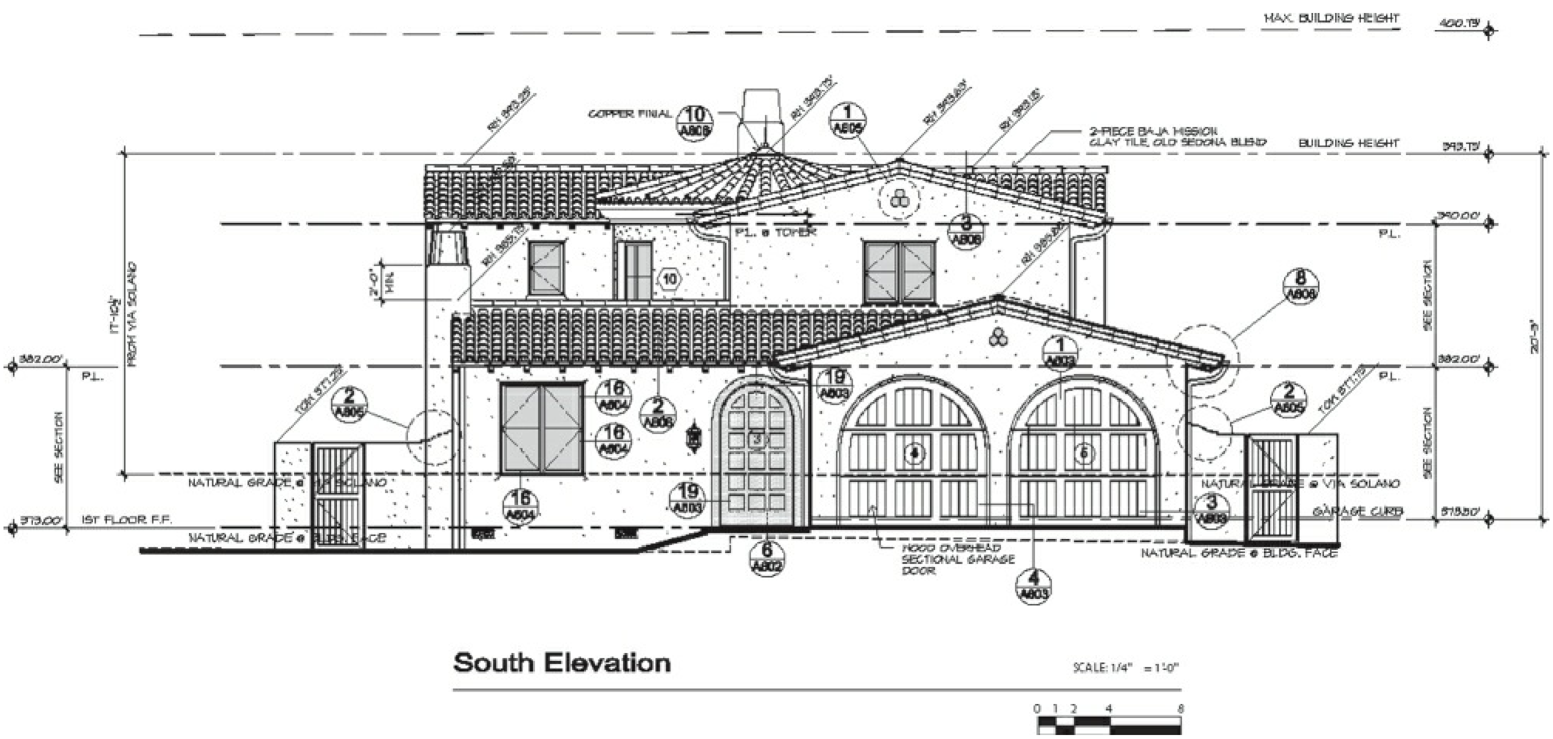


Figure 11.52 Stage VI: Noting and referencing.

(Courtesy of Mike Adli.)

CASE STUDIES: WORKING DRAWING DEVELOPMENT

In this section, we discuss the development of the exterior elevation working drawings for the Clay Theater steel and masonry building (Chapter 18) (see Figure 11.53A and B).

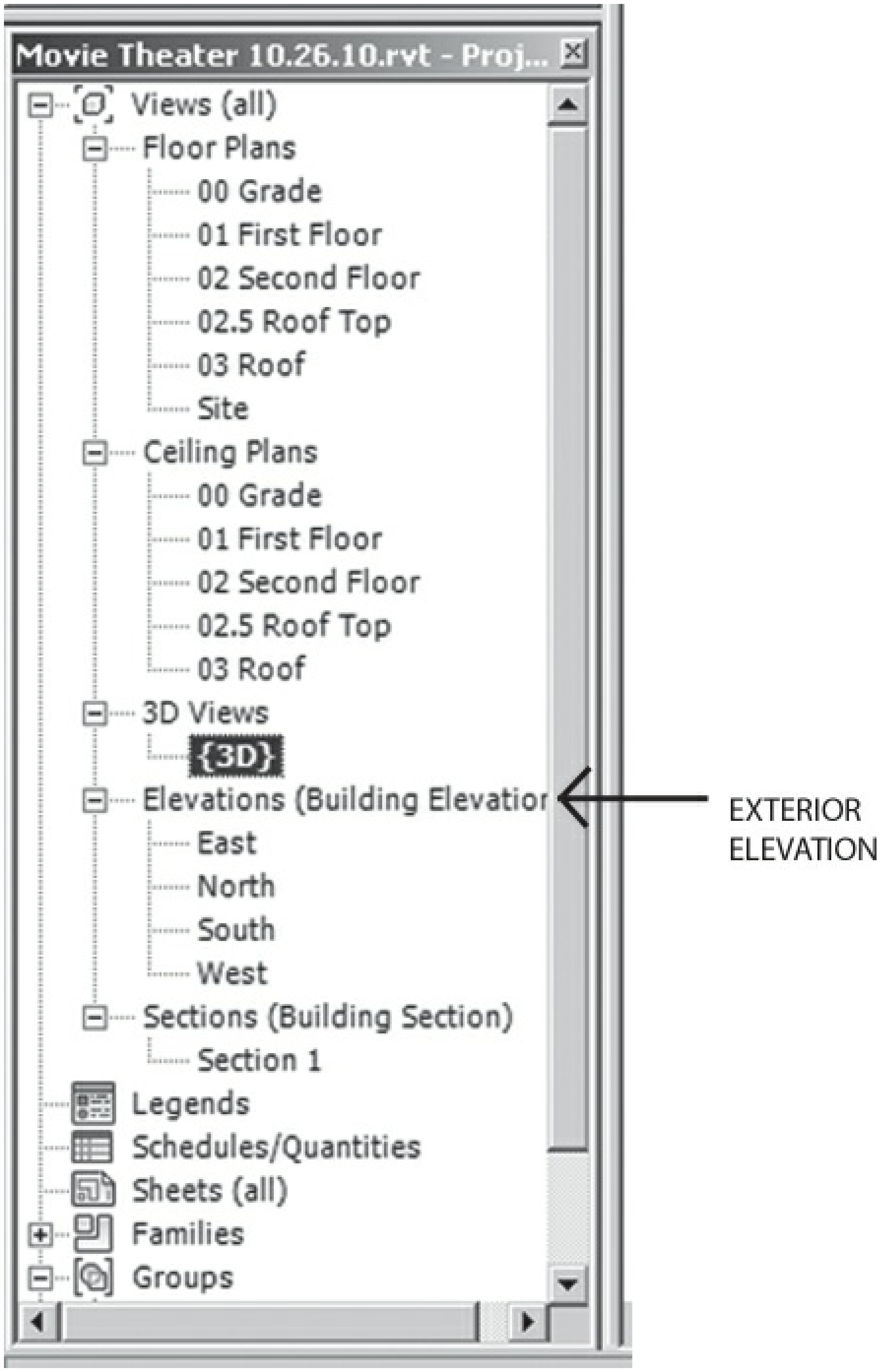


Figure 11.53A Exterior elevation menu.

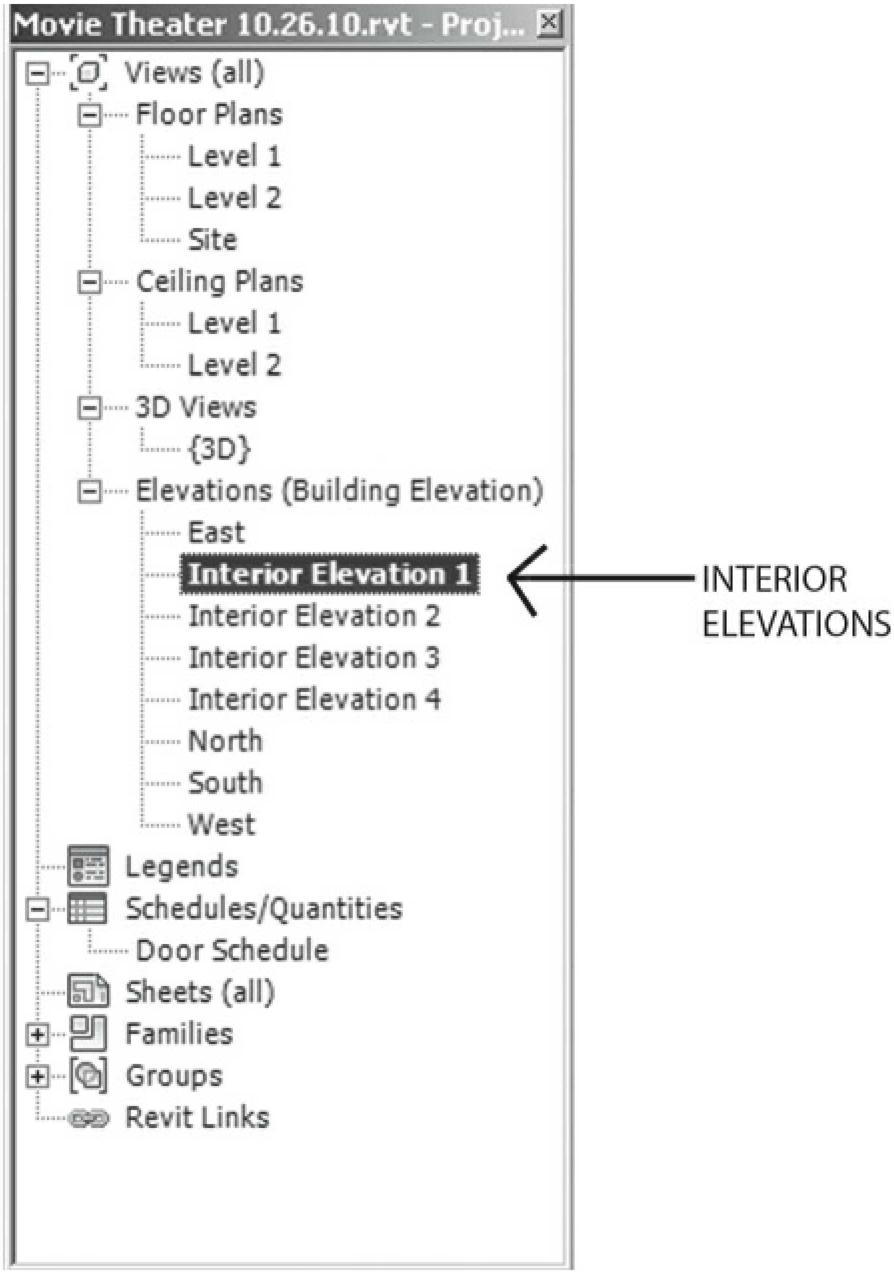


Figure 11.53B Interior elevation menu.

Clay Theater—Steel/Masonry Structure

Exterior Elevations. Elevations are developed from scratch, and are not traced from any other drawings unless extremely accurate preliminary drawings have been prepared. Figure 11.53 demonstrates the menu used for exterior elevations. In most sets of drawings, the elevations are among the last to be completed because they are dependent on the floor plan, sections, roof plan, and so on. To better see how exterior elevations evolve, first read the chapter on building sections (Chapter 12). Figures 11.54 and 11.55 show how the exterior of the project actually appears as the construction proceeds, and Figures 11.56 and 11.57 show front and rear views of the construction when completed.

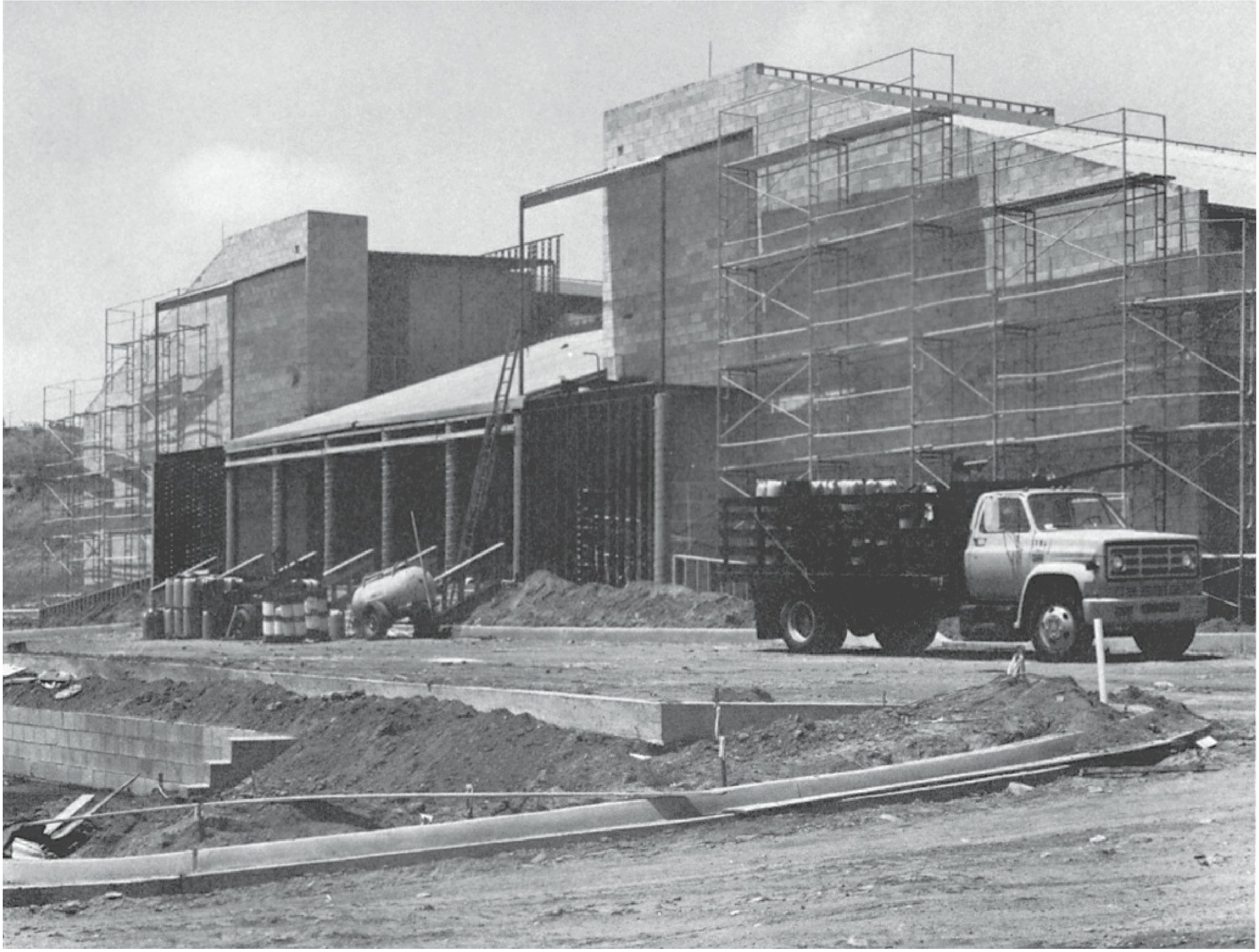


Figure 11.54 Front of theater.

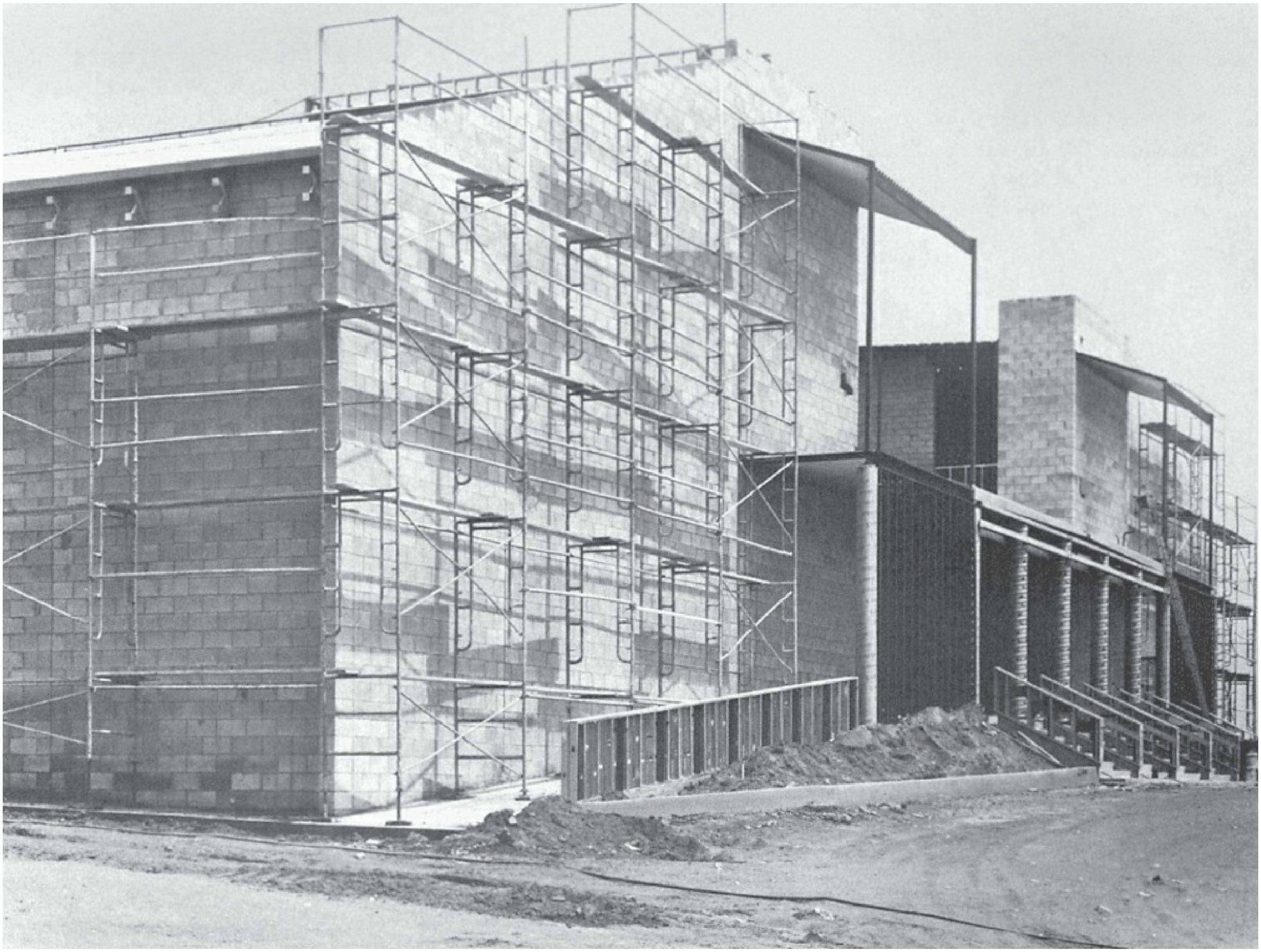


Figure 11.55 Front of theater showing ramp for disabled persons.

Figure 11.56 Front view of finished structure.

Figure 11.57 Rear view of finished structure.

Stage I

We decided to draft only three exterior elevations rather than the normal four because the structure is symmetrical and the north and south elevations are similar. The

horizontal lines in Figure 11.58 represent several items: the two floor levels, the top of the parapet, the tops of the beams, and the tip of the beam at the canopy over the door. (The sloped, dotted line on the bottom elevation is the angle of the ramp for persons with disabilities.)

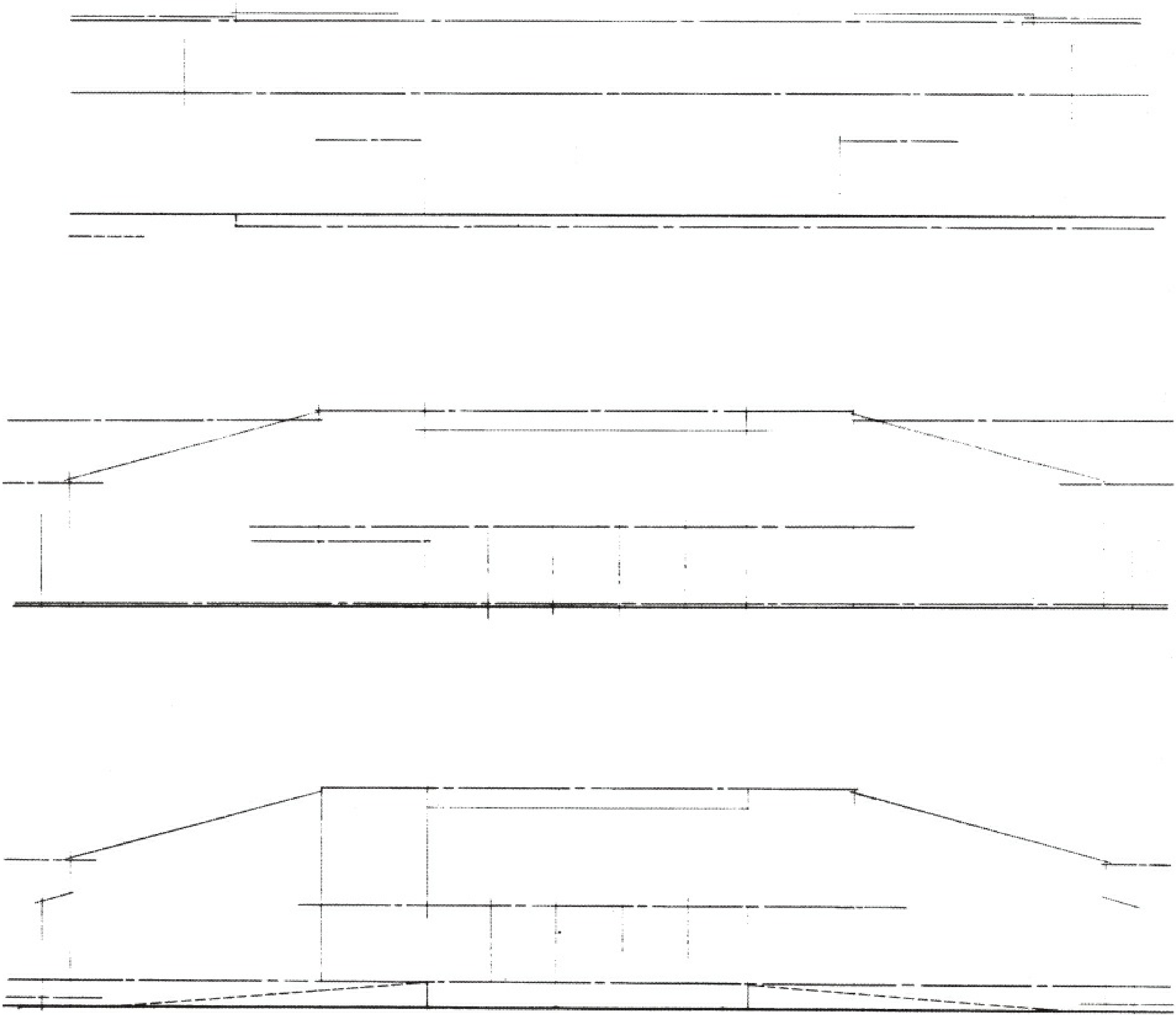


Figure 11.58 Elevation stage I

Stage II

The small, light vertical lines shown in Figure 11.59 locate the various beams and columns. These locations were taken from the reference bubbles on the floor plan. The complete structure would later be referenced by the column locations.

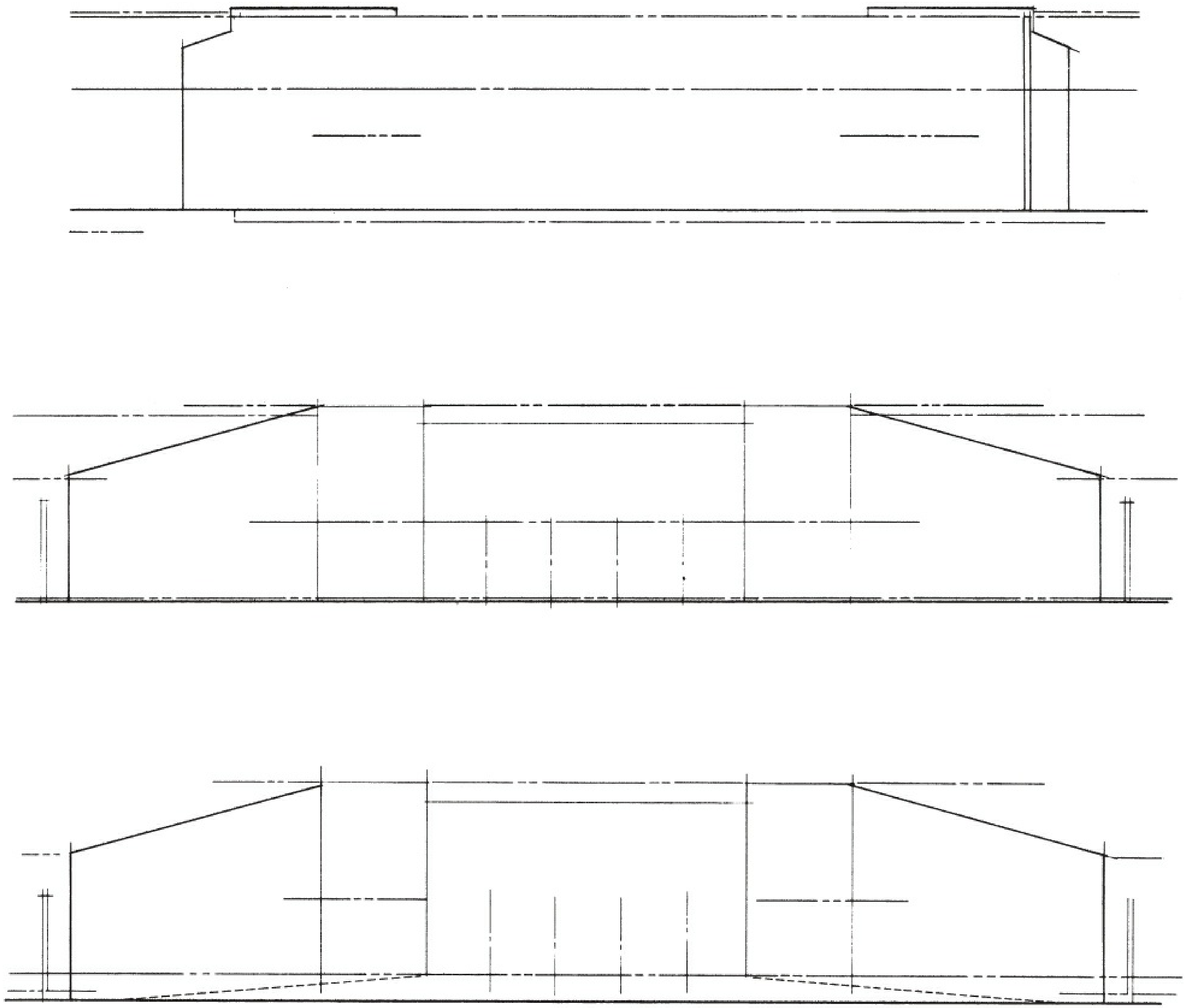


Figure 11.59 Elevation stage II

Stage III

Where Stage II indicated the vertical heights, Stage III established the outline of the building itself. See Figure 11.60. Column locations, wall thicknesses, independent walls at the exit were all established at this point. These measurements were obtained from the various plans, such as the floor plan, foundation plan, and the architectural sections. Each of these drawings used a dimensional system. This was helpful in the development of this structure because it gave specific points of reference. Heights, width, and depth of the structure were all referenced to this system. For orientation purposes, the top elevation is the north elevation; the center is the west elevation; and the bottom is the east elevation and entry to the theater. The two rectangular shapes toward the center of the north elevation represent the walls protecting the patrons at the exit.

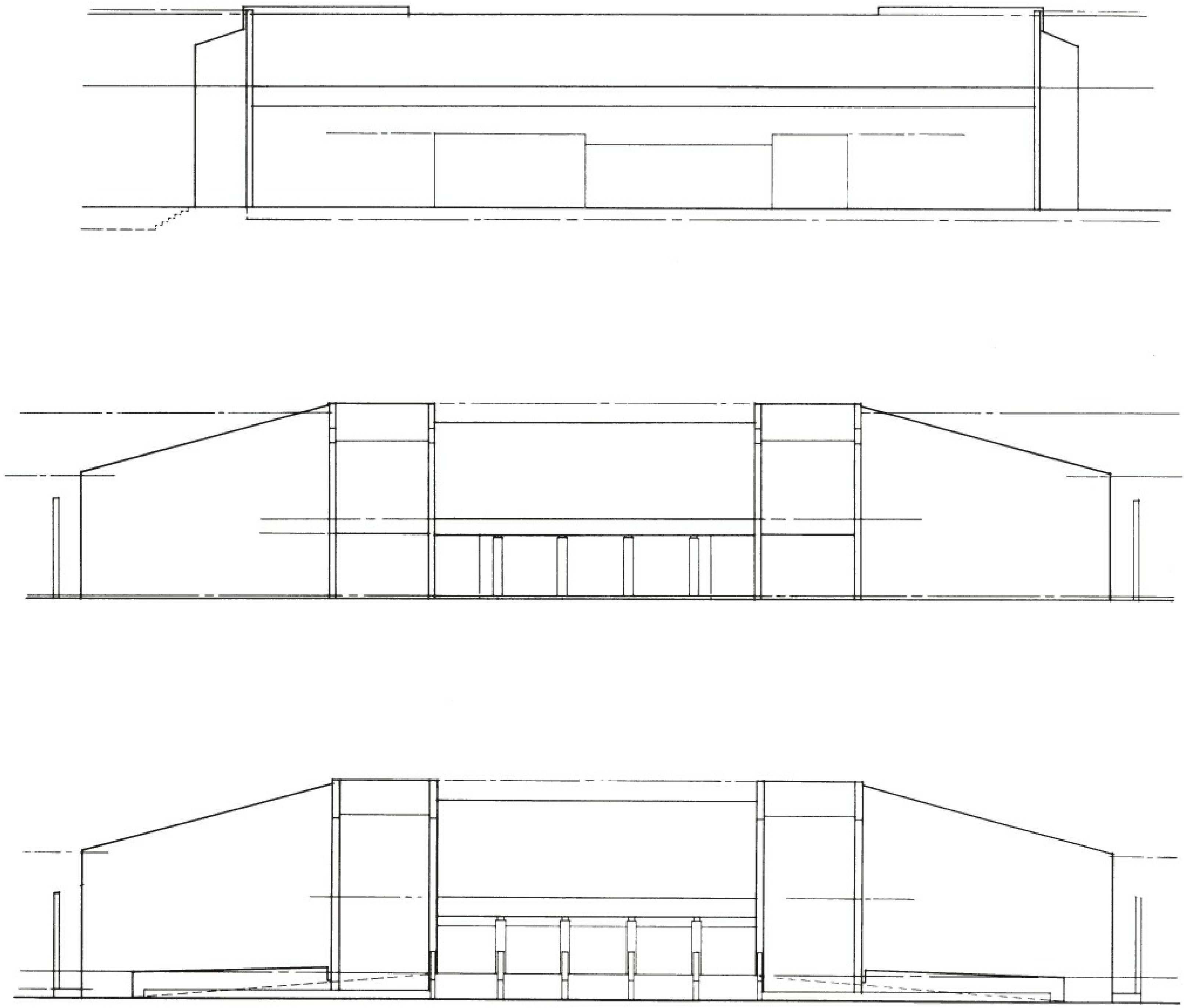


Figure 11.60 Elevation stage III

The top centerline on the west elevation is a point of reference. It is the top of the parapet wall extending above the roof plan. The series of vertical lines toward the center represent columns, and the two horizontal lines above the columns represent the fascia. The ramp on either side of the entry is indicated with dotted lines. See the east elevation in Figure 11.60. At the center are columns with handrails drawn in front of them. Stairs would be added later.

Stage IV

Now that we had a basic configuration, we could describe some of the smaller shapes. See Figure 11.61. We added the arbor, or shaded walk, to the north elevation. Refer back to Figure 11.57. The line above the wood arbor is the wood frieze (band of wood). The opening is located at the left. To the west elevation we added rear doors, the doors for the

storage area, and the arbor at each end. We positioned steps and doors on the east elevation.

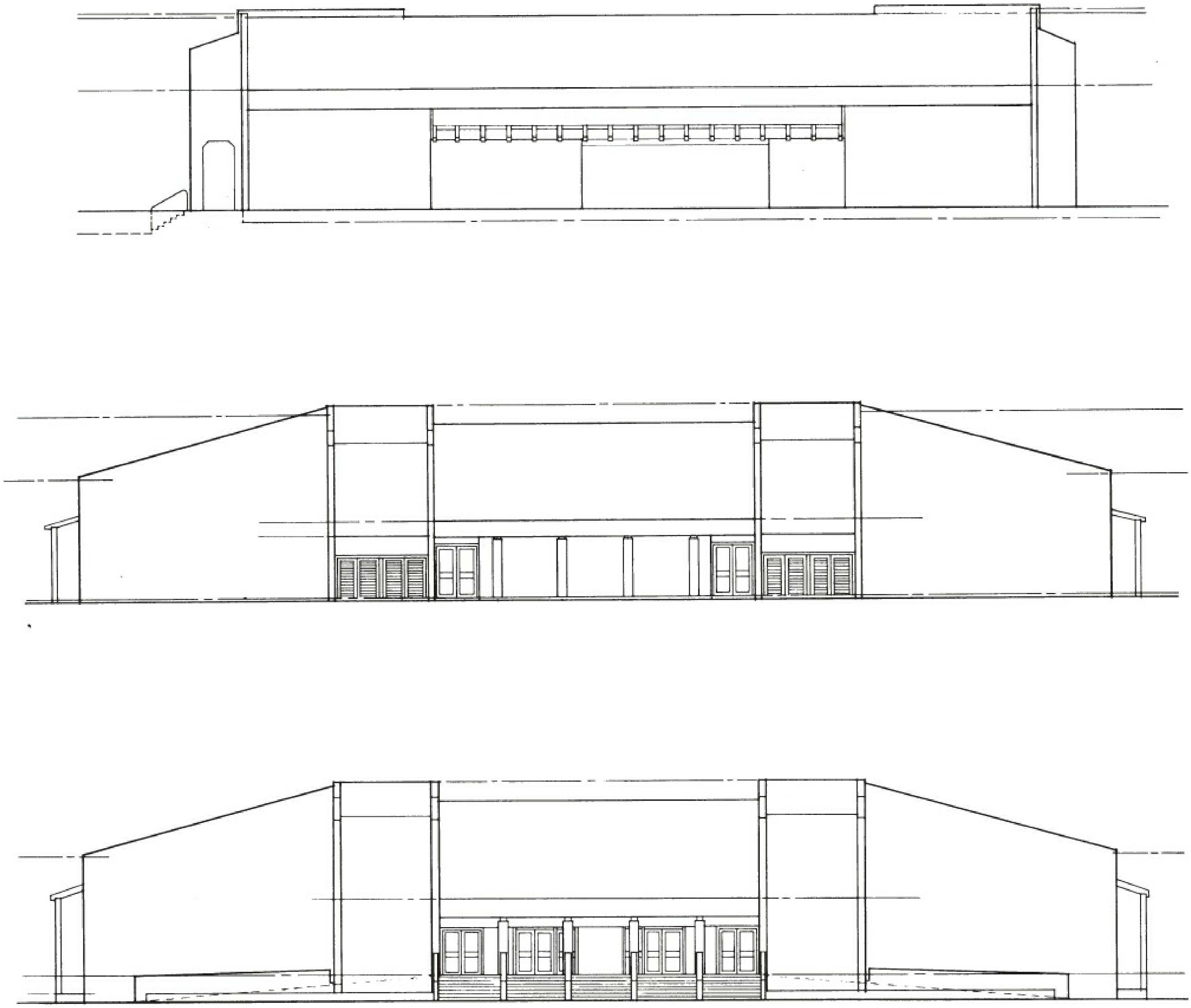


Figure 11.61 Elevation stage IV

Madison—Steel Building

Exterior Elevations

Stage

The initial preparation for developing the exterior elevations begins with drawing in light broken lines, which will indicate the floor line level for the various floors. This is done for all four of the exterior elevations. In this stage, the ground level is represented with a solid line. The CAD operator uses this drawing for the layering or tracking of all future drawings of the exterior elevations. The initial drawing for Stage I of the exterior

elevations is depicted in Figure 11.62.

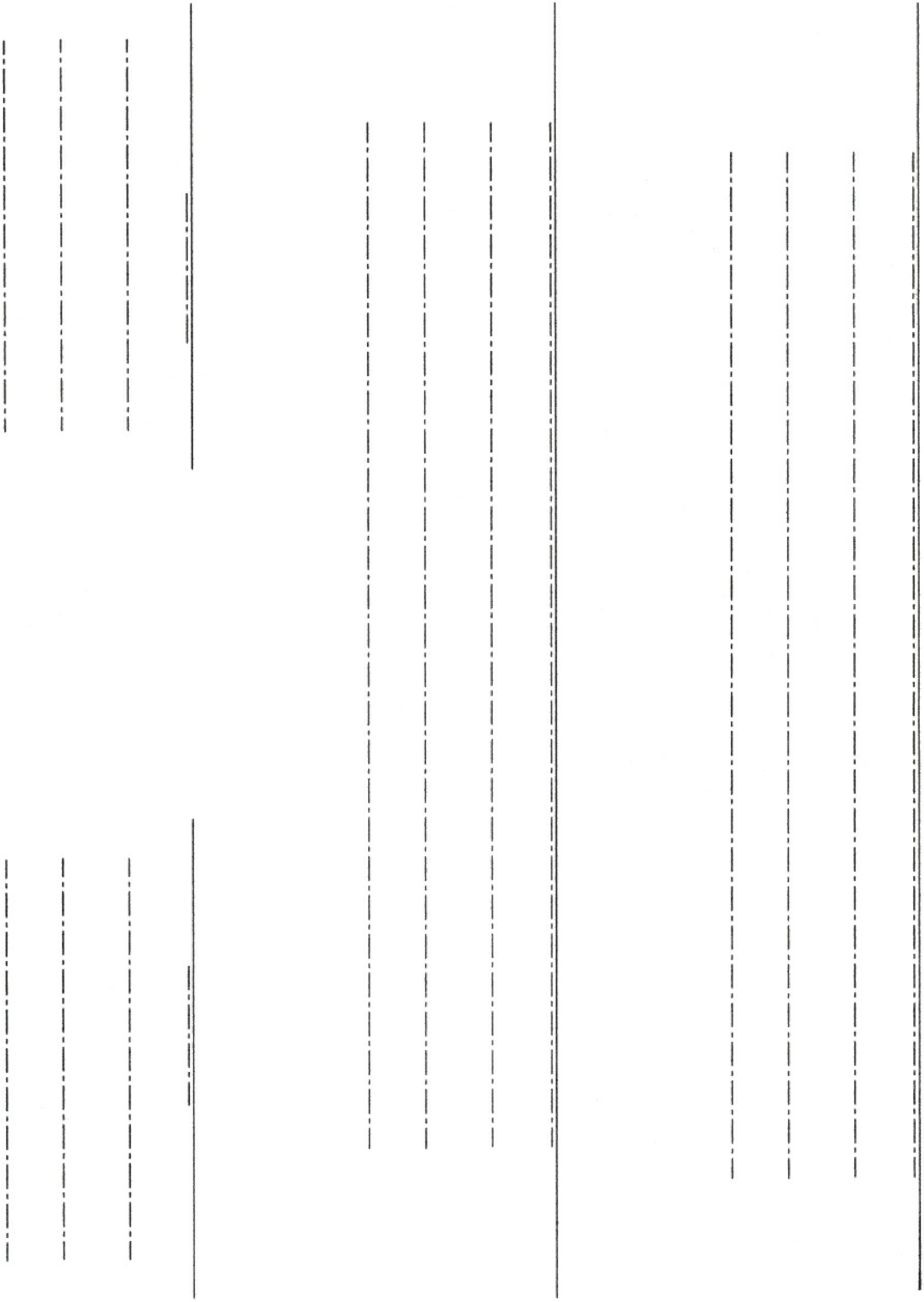


Figure 11.62 Madison Building—Stage I: Working drawings—exterior elevations.

Stage II

After determining the ground level and the other floor levels, we use a solid vertical line to identify the exterior wall extremities on the various sides of the exterior elevations.

This drawing indicates the general massing of the building. Stage II is shown in Figure 11.63.

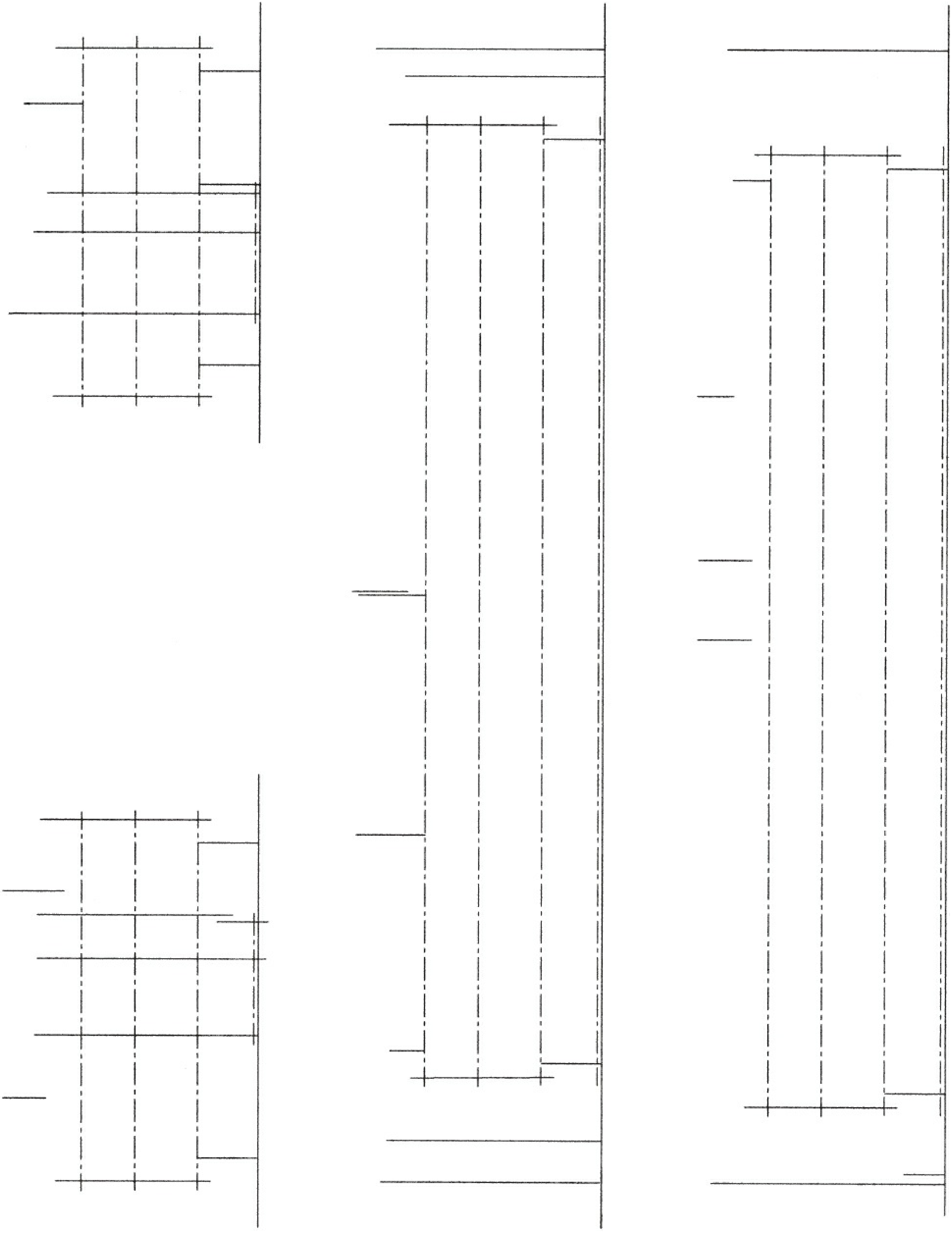


Figure 11.63 Madison Building—Stage II Working drawings—exterior elevations.

Stage III

In Stage II, the various exterior wall extremities for the building elements were established. Stage III is drawn to refine all the horizontal and vertical masses of the structure. This refined dimensional drawing illustrates the heights of the roof and floor masses while indicating the height of the continuous window band. Many design refinements are created at this stage. These refinements include avoiding square edges at the roof, floor, and wall masses. This was done to give the building a sculptured appearance. To provide compatibility with the sculpting of the building, it was decided to encase the exposed rectangular steel columns in concrete for two primary reasons.

First, the fluid nature of concrete could be utilized in sculpting the columns. Second, the concrete could provide a larger proportional mass to the main supporting columns. Note the two vertical lines representing the main supporting columns. This particular column detail is illustrated later in the chapter. The roof and window elements for the mezzanine level above the third floor are shown at this stage. Stage III of the exterior elevations is illustrated in Figure 11.64.

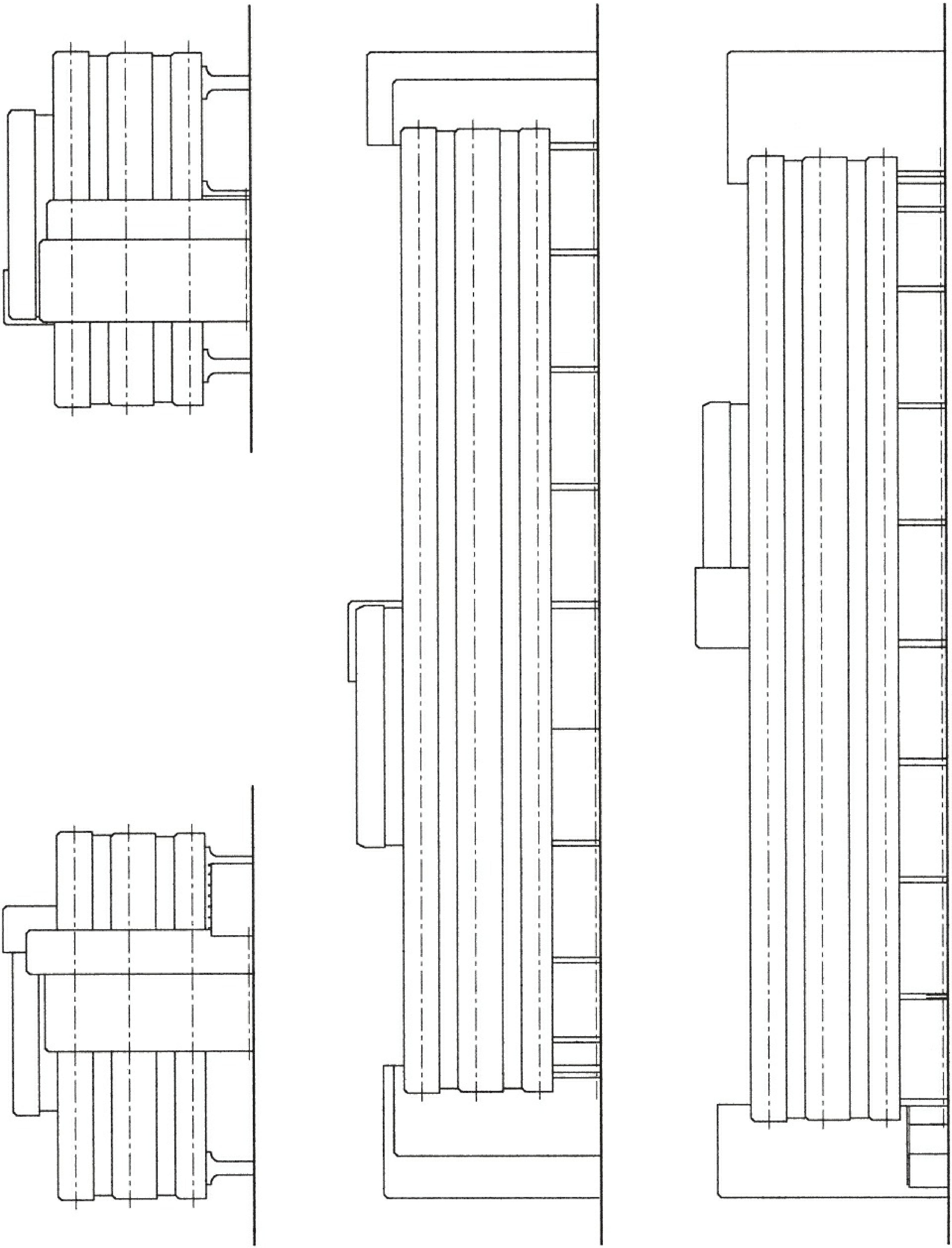


Figure 11.64 Madison Building—Stage III: Working drawings—exterior elevations.

Stage IV

After establishing the basic elements for the four exterior elevations, refinements within those elements are added. These include the vertical window mullions, glass entry doors, and the adjacent glazing in the lobby area, and the access gates at the trash area. It was decided to provide round sculptured openings in the masonry shear walls at this stage. This was done after consulting with the structural engineer. Figure 11.65 depicts Stage 4.

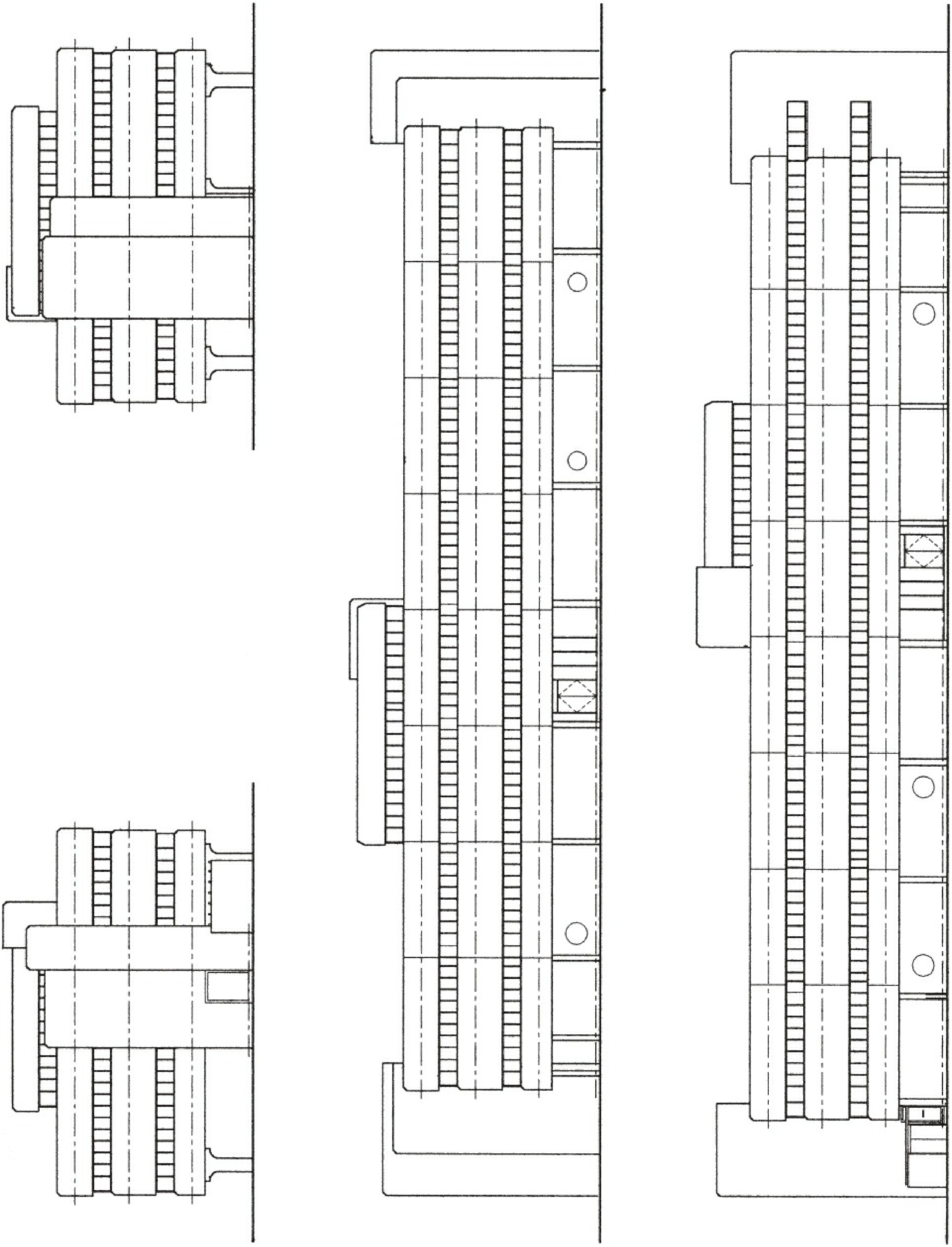


Figure 11.65 Madison Building—Stage IV: Working drawings—exterior elevations.

Stage V

The drawing of Stage V depicts the shading of all the glazing areas and the gradation of vertical lines that are simulating the curved wall edges, corners of the roof sections, and the floor masses. It was decided to shade the glazed areas for the purpose of providing greater clarity.

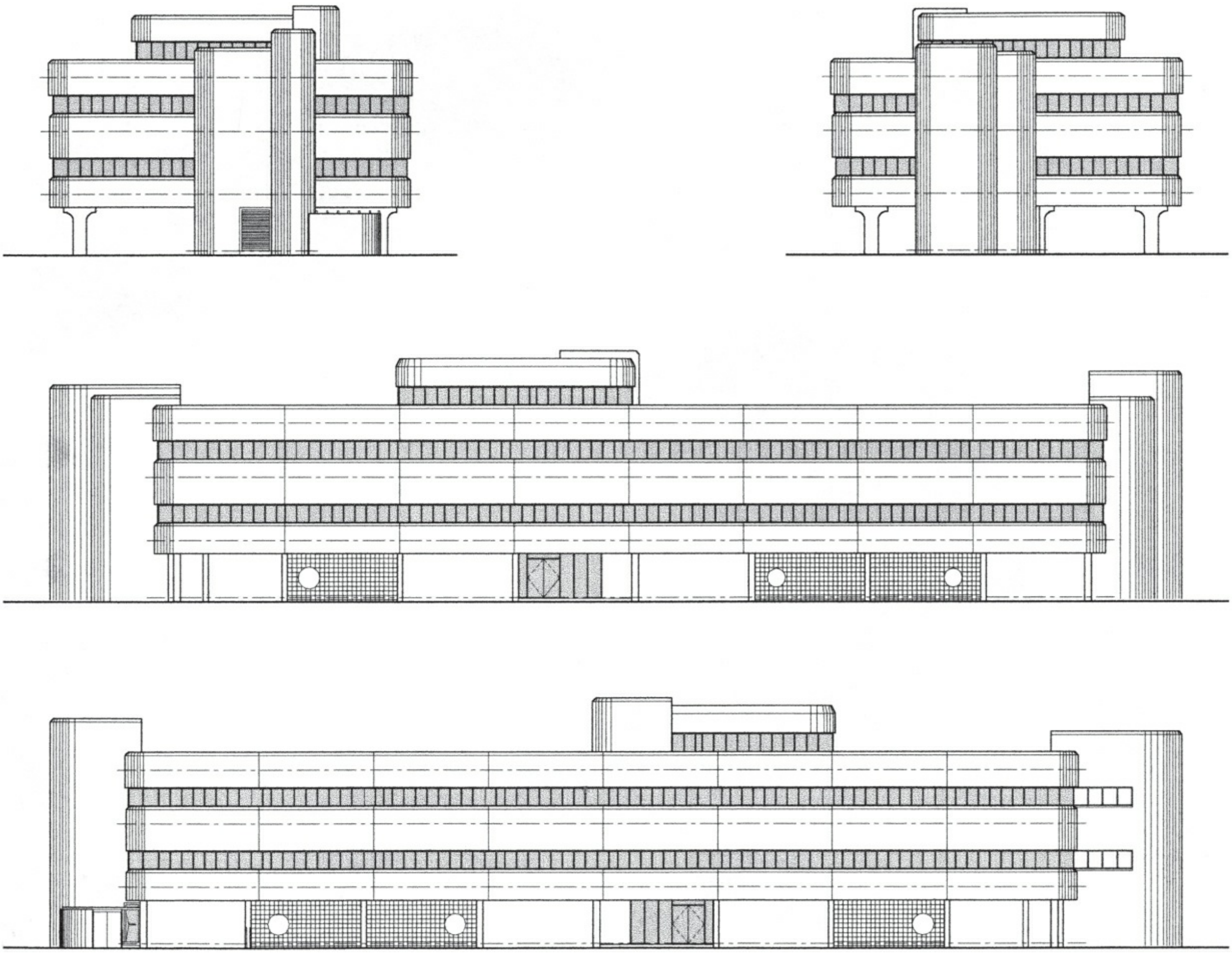


Figure 11.66 Madison Building—Stage V: Working drawings—exterior elevations.

INTERIOR ELEVATIONS

Purpose

The whole purpose of ***interior elevations*** is to expose the interior walls so as to locate fixtures, appliances, and cabinets and reveal any additional framing necessary to accommodate fixtures. Interior elevations are necessary when the architect wants to

control the visual effects of the interior walls of the structures. Although normally such elevations are not part of the submission, building departments do require an interior elevation showing Americans with Disabilities Act (ADA)…compliant elements.

This section gives many examples of interiors, from residential structures as well as commercial and industrial buildings.

For interior elevations, you draw an outline of what you see, based on the measurements of the ceiling height and the width of the walls. Things that are not in the contract are not drawn solid. For example, a refrigerator often is not included in the contract; neither are the washer and dryer. Hence, these should be drawn with a hidden (dotted) line so as to reveal the wall behind, to show the construction of the base molding and/or the outlets needed to power the particular appliance. If there are no cabinet details, the cabinet form coming toward the viewer should be shown in profile instead of voided out, as previously discussed. Do not forget to show the base molding!

Sources of Measurements

Use the floor plan and building sections for accurate measurements of the width and height of an interior elevation wall. When you use these plans, remember that these dimensions are usually to the stud line or centerline of the wall. Interior elevations are drafted to the plaster line.

Interior elevations may not always be drafted at the same scale as the floor plans or sections. Because this requires a scale transition, use caution to avoid errors. In some of the examples in this chapter, the same scale is used and the drawings are directly projected from the plan and section; this is done only to show the theory of where to obtain shapes and configurations.

Information Shown on Interior Elevations

Some architectural offices draft interior elevations for every wall of every room. Although this very careful approach can avoid errors, many wall surfaces are so simple that they do not require a formal drafted interior elevation. These simple walls depend primarily on the interior finish schedule for their proper description.

Use interior elevations when you need to convey an idea, dimension, construction method, or unique feature that is better described by drafting than by a written description in the specification. For example, in a residence, the kitchen, bathrooms, special closets, and wet bars have walls that are usually drafted. On a commercial structure, you may select typical office units, showing bookcases, cabinets, display cases, and so on. In an industrial structure, you may draw the locations of equipment, conveyor belts, and special heights for bulletin boards or tool racks.

In short, interior elevations are the means of controlling the construction and surface finishes of the interior walls of a structure, and of providing information to contractors. If the contractor does not have the expertise or personnel to do a specific task, specialists

(*subcontractors*) will be brought in to assist.

Naming Interior Elevations

In exterior elevations, the titles assigned—North, South, East, and West—are based on the direction the structure faces. In interior elevations, this is reversed: The title is based on the direction in which the viewer is looking. For example, if you are standing in a theater lobby facing north, the interior wall you are looking at has the title "North Lobby Elevation" (see Figure 11.67). To avoid confusion when you are naming an interior elevation, use reference bubbles like those shown in Figure 11.68.

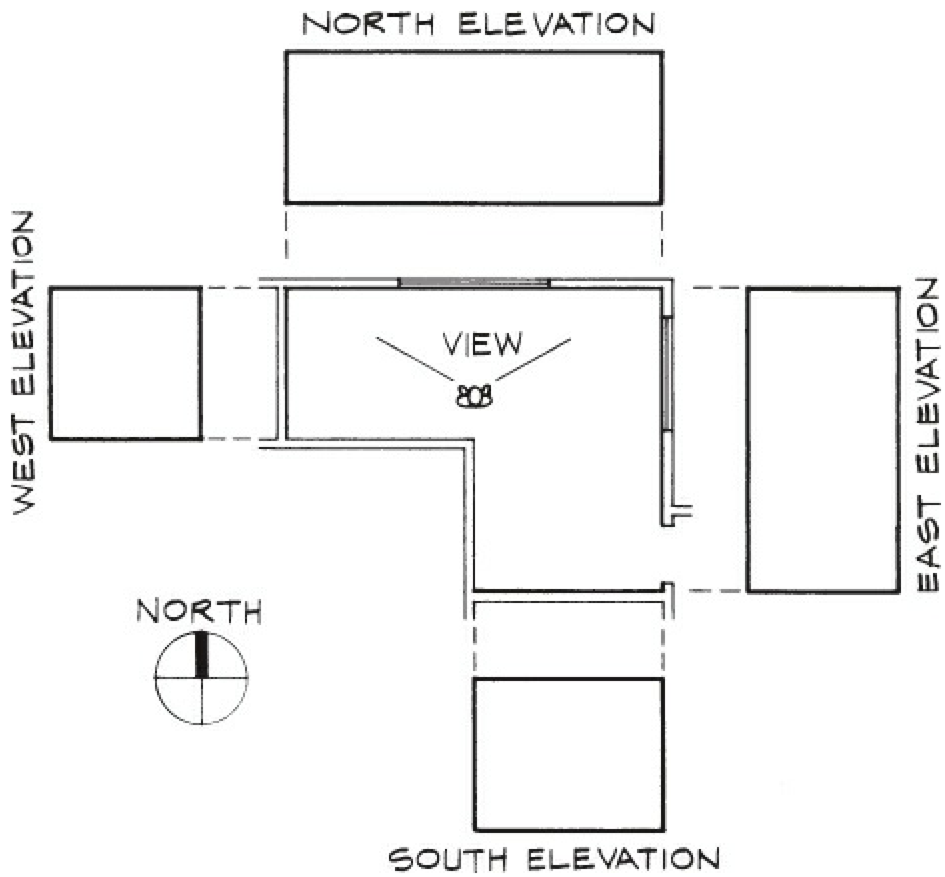


Figure 11.67 Naming interior elevations.

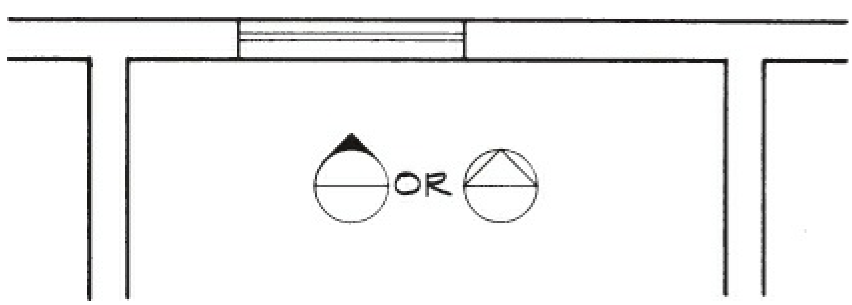


Figure 11.68 Interior elevation reference bubbles.

The reference symbol shown on the left is the same as the one used in the foundation plans and framing plans to refer to details. Remember that the reference bubble is a circle with a darkened point on one side, which points to the elevation being viewed and drawn.

The reference symbol shown on the right in Figure 11.68 shows a circle with a triangle inside it. The point of the triangle tells the viewer which elevation is being viewed, and

the placement of the triangle automatically divides the circle in half. The top half is filled in with a letter or number, which becomes the name of that interior elevation. The lower half contains the sheet number on which the interior elevation can be found (see also Figures 11.69 and 11.70).

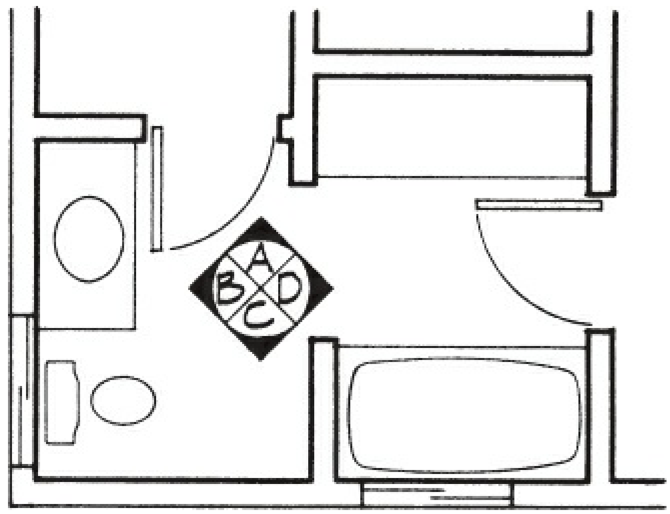


Figure 11.69 Symbol used to show multiple interior elevations.

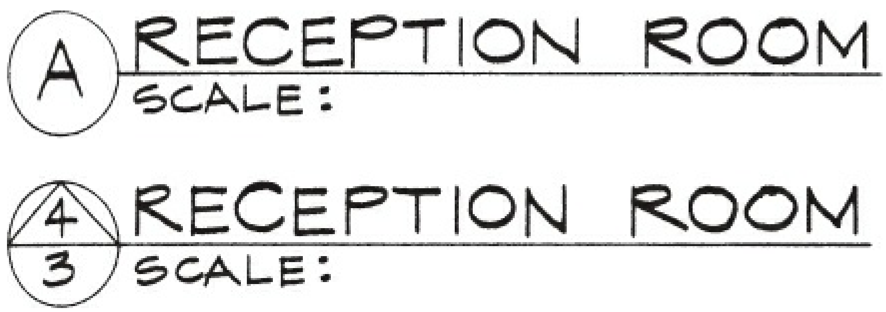


Figure 11.70 Interior elevation titles.

Figure 11.69 shows a floor plan and a symbol used to show multiple elevations. Letter “A” is for the north elevation, “C” is for the south elevation, “B” for the west elevation, and “D” for the east elevation. Figure 11.70 shows two types of *title references* (manner in which the interior elevations are titled for ease of cross‐references with the floor plan).

Choosing a Scale

The most desirable scale for an interior elevation is ½″ = 1′‐0″. Most floor plans are drafted at ¼” = 1′‐0″, so using the half‐inch scale makes the translation from floor plan to interior elevation easy: You only need to use a pair of dividers and double every measurement. Interior elevations are seldom drawn larger than this.

If the drawing space does not permit you to use a ½″ = 1′‐0″ scale, or if the scale of the drawing calls for a smaller interior elevation, you may use a 3/8” = 1′‐0″ or ¼” = 1′‐0″ scale. The scale could also depend on the complexity of the wall to be shown.

Using Hidden Lines (Dotted Lines)

Dotted lines are used extensively on interior elevations. As in the drafting of exterior

elevations, the dotted line is used to show door…swing direction—for example, for cabinets or for bifold doors on a wardrobe closet. See Figure 11.71. Dotted lines are also used to represent items hidden from view, such as the outline of a kitchen sink, shelves in a cabinet, or the vent above a hood vent, range, or cooktop.

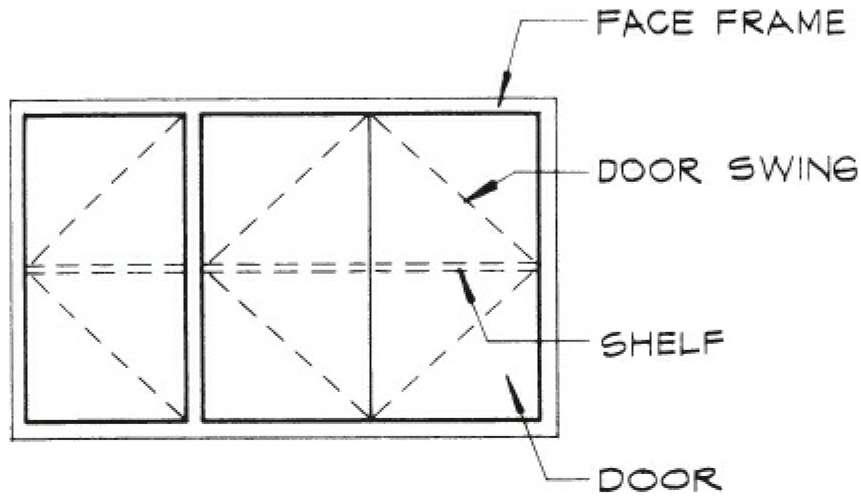


Figure 11.71 Typical elevation of cabinet.

Dotted lines are also used to show the outline of objects to be added later or those *not in the contract* (designated as *NIC*). For example, the outline of a washer and dryer or refrigerator is shown; even though the appliances themselves are NIC, space must be allowed for them. The wall behind the appliance is shown, including duplex convenience outlets, and molding or trim at the base of the wall.

Other Drafting Considerations

To draft interior elevations of cabinets, you must know the type, countertop material, heights, general design, and number of cabinet doors.

There are three main types of cabinet doors: *flush*, *flush overlay*, and *lip*. As Figure 11.72 shows, flush overlay doors cover the total face of the cabinet. The front surface of the cabinet, called the *face frame*, does not show. The flush door is shown in Figure 11.73 and the lip door in Figure 11.74. Because the face frame of the cabinet shows when either lip or flush cabinet doors are used, the face frame appears the same in the interior elevation.

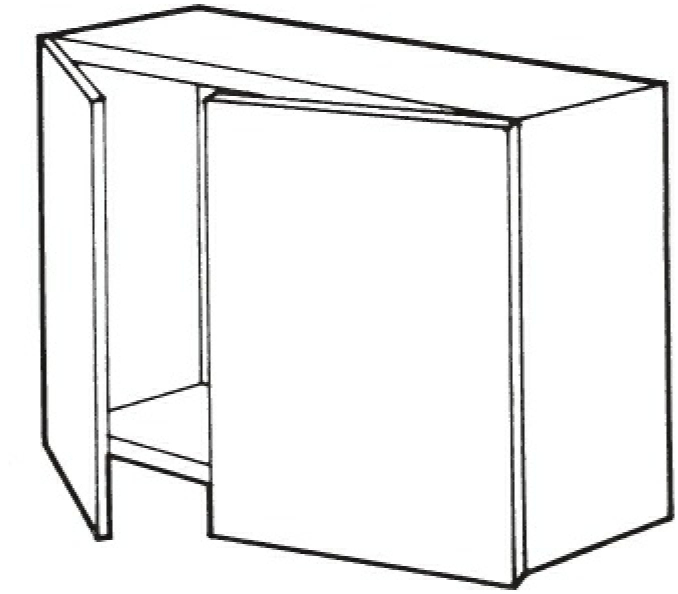


Figure 11.72 Flush overlay doors.

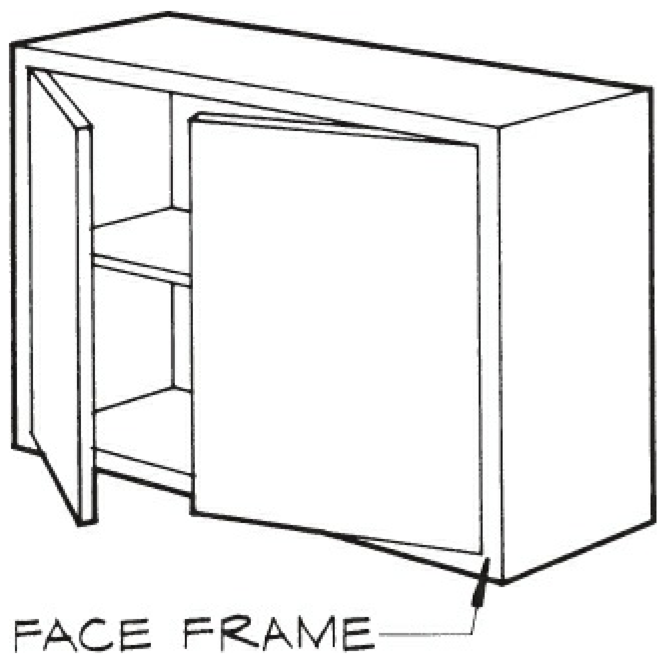


Figure 11.73 Flush doors.

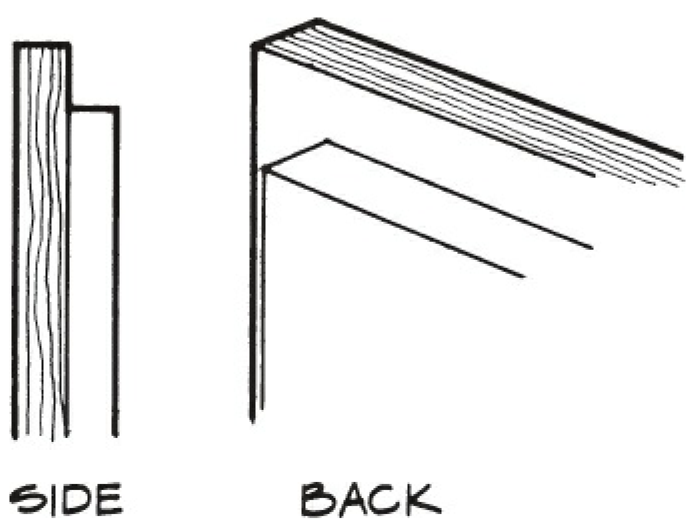


Figure 11.74 Lip door.

Material Designation and Noting

Materials for interior elevations are represented similar to the materials for exterior elevations. Noting is kept simple, and generic terms are often used. Specific information, brand names, workmanship notes, procedures, applications, and finishes are placed in the specifications. Later in this chapter you will see examples of generic noting for such items as ceramic tile countertops, an exhaust hood (with a note to "see specs"), and metal partitions.

Outline of Interior Elevations

The outline of an interior elevation represents the outermost measurement of a room. Objects that project toward the viewer, such as cabinets, beams, and air…conditioning ducts, are drawn. Some architectural offices deal with these as if they were in section, but most prefer to treat them as shown in Figures 11.75 and 11.76. Note in Figure 11.76 that the tops of the cabinets have been eliminated in drafting the outline of the cabinet.

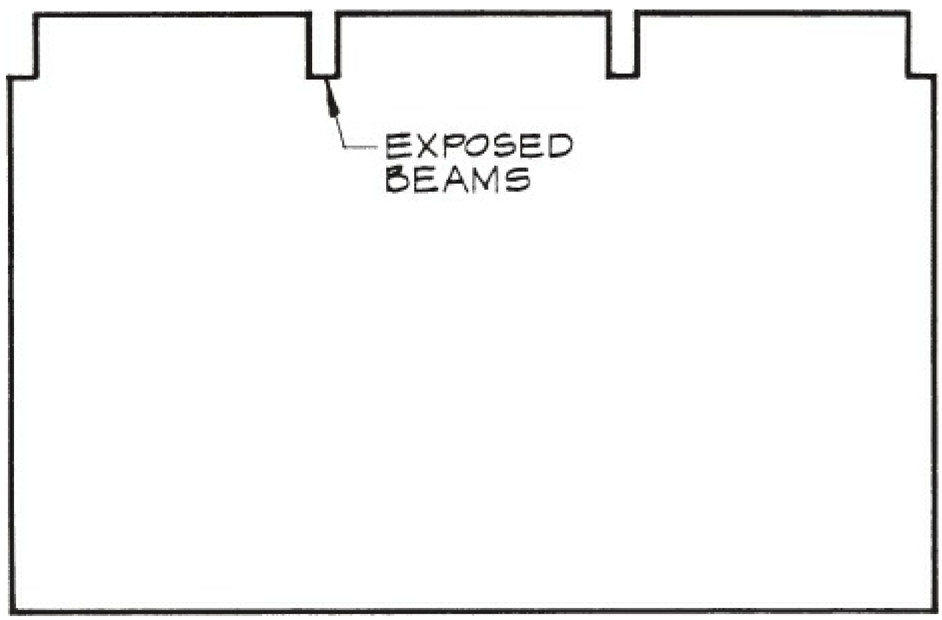


Figure 11.75 Exposed beams.

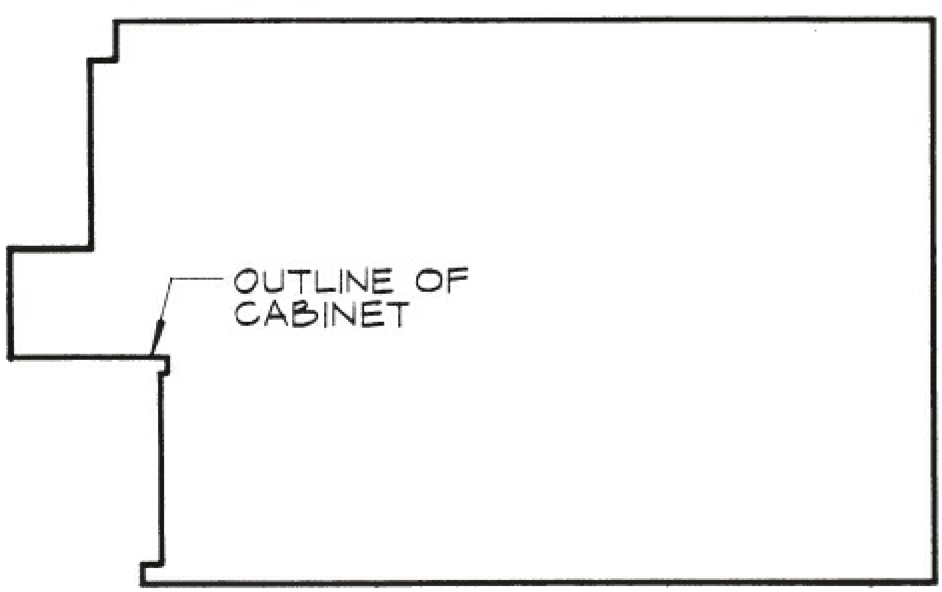


Figure 11.76 Outline of cabinet.

Planning for Children and Persons with Disabilities

Always have information available on standards affecting facilities that should be usable by children and persons with disabilities. Here are some of the standards established by several states for disabled persons:

1. Door opening: minimum size 2′…8″ clear
2. Restroom grab bars: 33″ to 36″ above the floor
3. Towel bars: 3′…4″ maximum above floor
4. Top of lavatory: 34″ maximum above floor
5. Drinking fountains: 3′…0″ maximum

Many standards can be obtained by writing to the proper authority, such as the state architect's office. Most standards are presented in the form of a drawing. See Chapter 1 for specifics, and see Figures 11.94 and 11.95 for examples.

DIMENSIONS AND INTERSECTIONS

Dimensions

When you draft a set of interior elevations, do not repeat dimensions that appear elsewhere. For example, you need not indicate the width of rooms on the interior elevation. In fact, avoid repeating dimensions at all costs.

In a similar way, you do not need to dimension the interior elevation of the counter shown in Figure 11.77, because it will occupy the total width of the room. The boundaries, which are the walls, are already dimensioned on the floor plan.

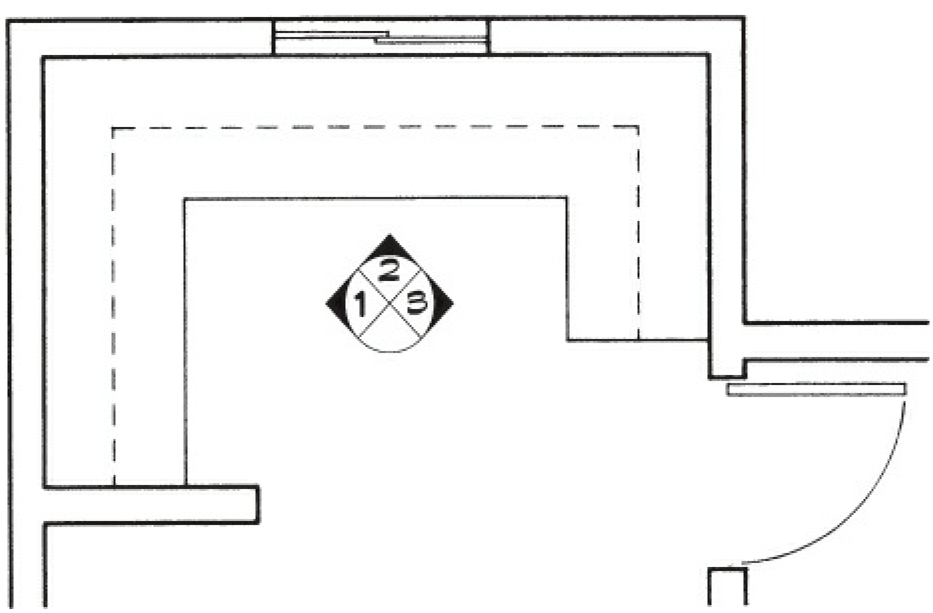


Figure 11.77 Partial plan of food preparation area.

The interior elevations for Figure 11.77 will show a counter, walls, window, and an opening. The portion of the counter that returns toward the opening should be dimensioned either on the floor plan or on the interior elevations, but not on both. See Figure 11.78.

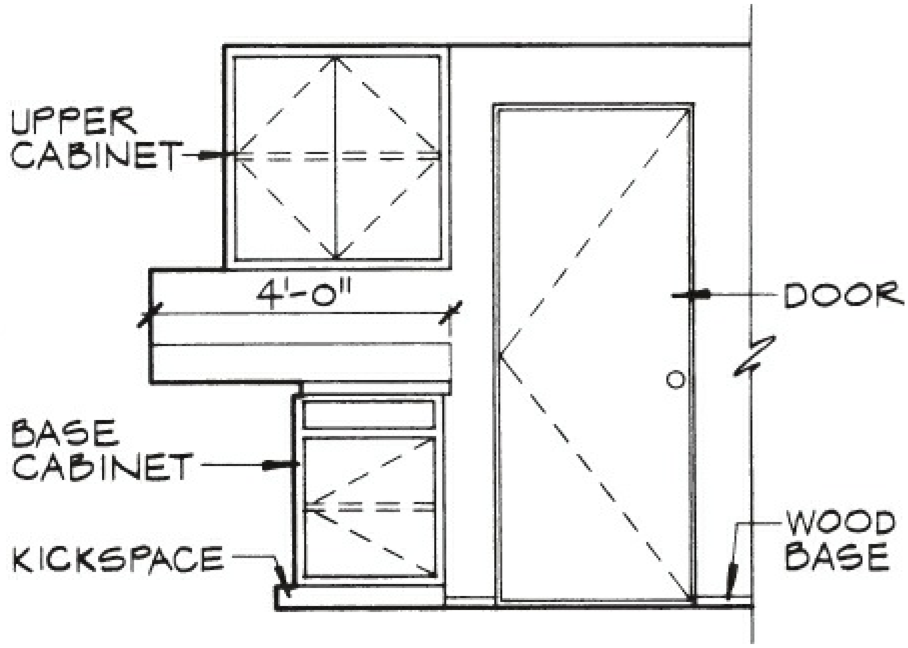


Figure 11.78 Partial interior elevation.

Notice how the base cabinet is dimensioned; in fact, the space between the door and the cabinet could have been dimensioned instead. Deciding whether to dimension the space or the cabinet is based on which is more important. If the space is left for an appliance or some other piece of equipment, then the space should be dimensioned.

The interior elevation is also the place to provide such information as the location of medicine cabinets, the heights of built…in drawers, the locations of mirrors, the required clearance for a hood above a range, and the heights of partitions.

Intersection of Wall and Floor

Interior elevations can also show, in a simple way, the wall and floor intersection. This can be achieved by applying a topset, covering the floor, or using a base or a base and a shoe. This creates a transition between the floor and wall planes. *Topset* is made of flexible material such as rubber and placed on the wall where it touches the floor. With ***coving***, the floor material is curved upward against the wall. A ***base*** is used to cover, or as a guide to control, the thickness of the plaster on the wall, and a *shoe* covers the intersection between the wall and floor. See Figure 11.79.

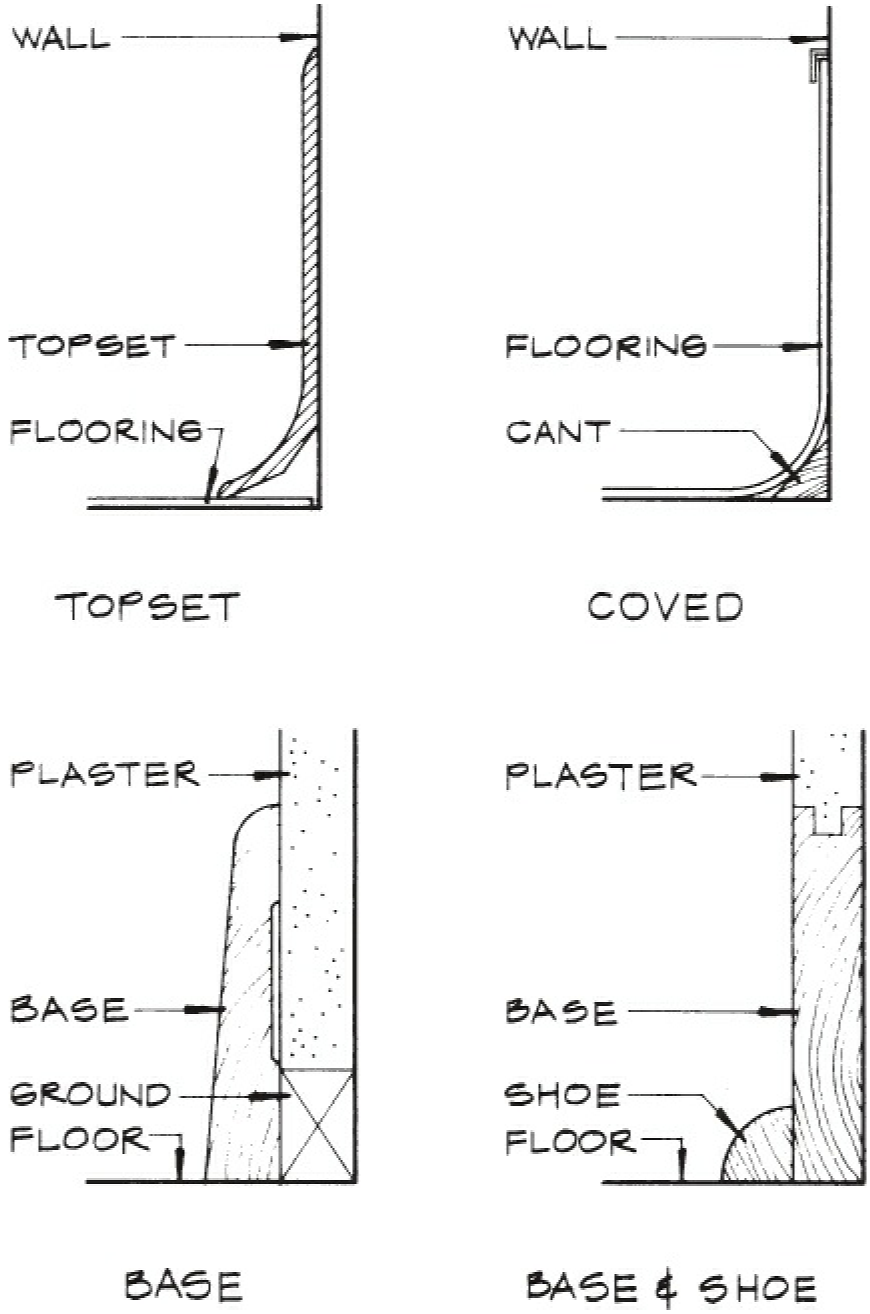


Figure 11.79 Intersection of wall and floor.

DRAFTING AN INTERIOR ELEVATION: EXAMPLES

A Kitchen

Figure 11.80 shows a perspective view of a kitchen. The main portion has lip doors on the cabinets, and the extreme left side (not shown in the perspective) has flush overlay doors. Different types of cabinet doors are not usually mixed on a single project; here the intention is simply to show the different methods used to represent them on an interior elevation. Figure 11.81 shows a floor plan of the perspective drawing in Figure 11.80. Note the flush overlay cabinet on the left and the lip or flush cabinets on the right. The upper and base cabinets, slightly to the left of center, project forward.

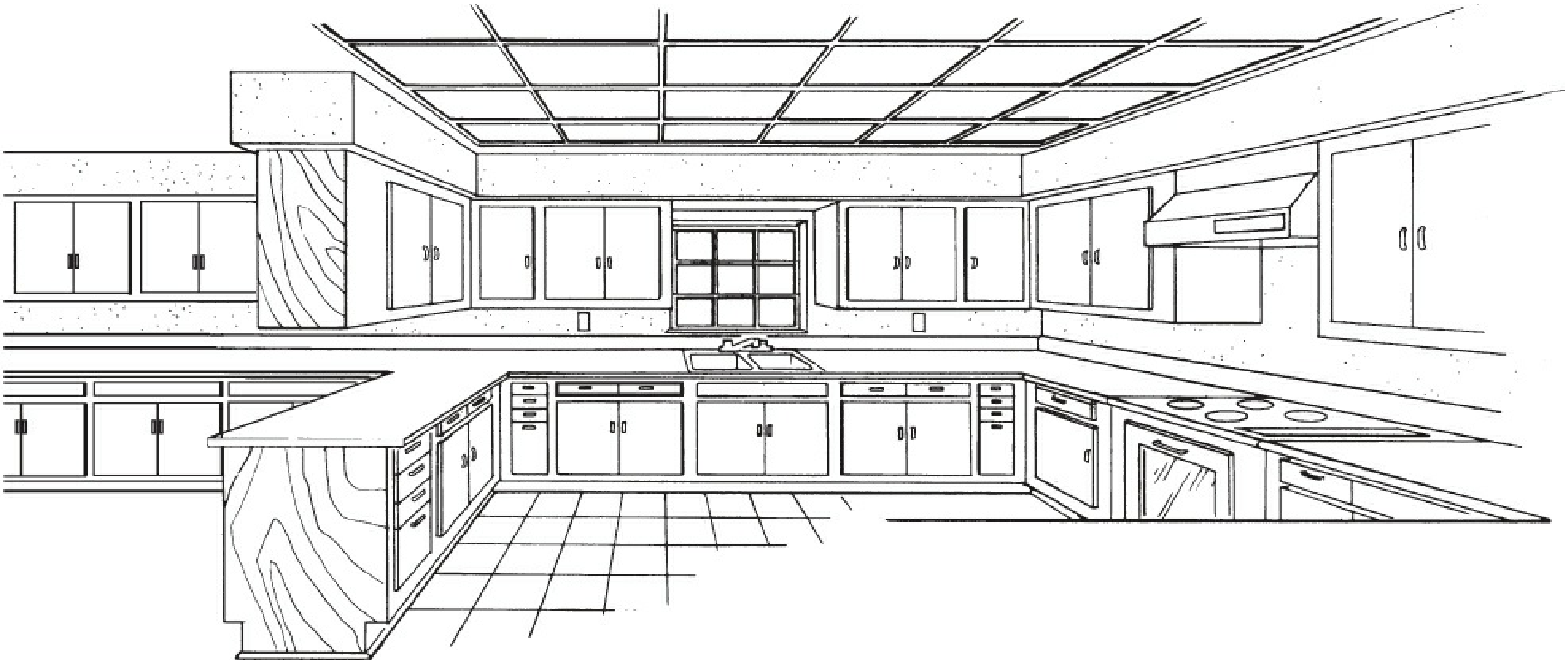


Figure 11.80 Perspective view of a kitchen.

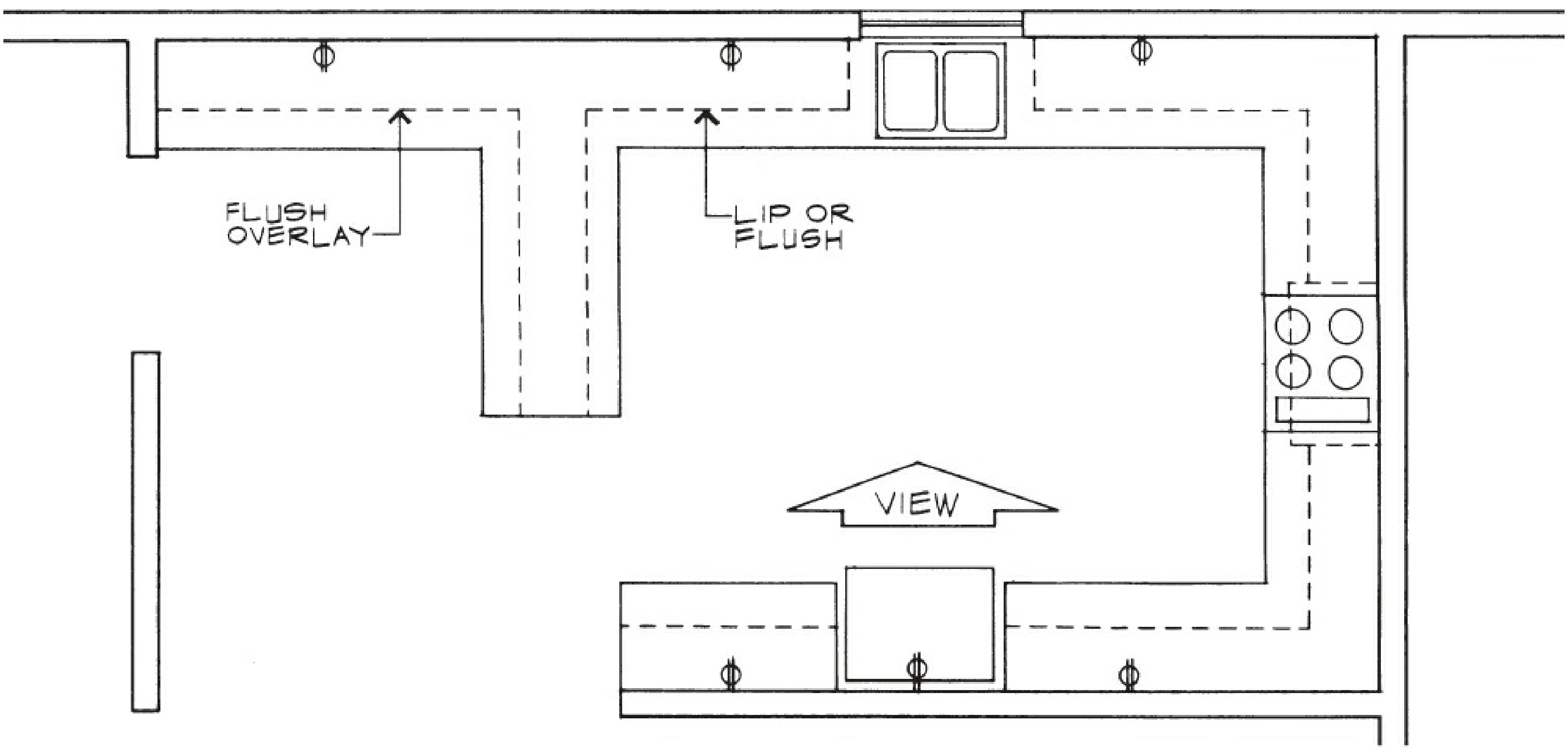


Figure 11.81 Partial floor plan of kitchen.

Figure 11.82 shows the drafted interior elevation of one side of the floor plan of the kitchen. You should take careful note of these points:

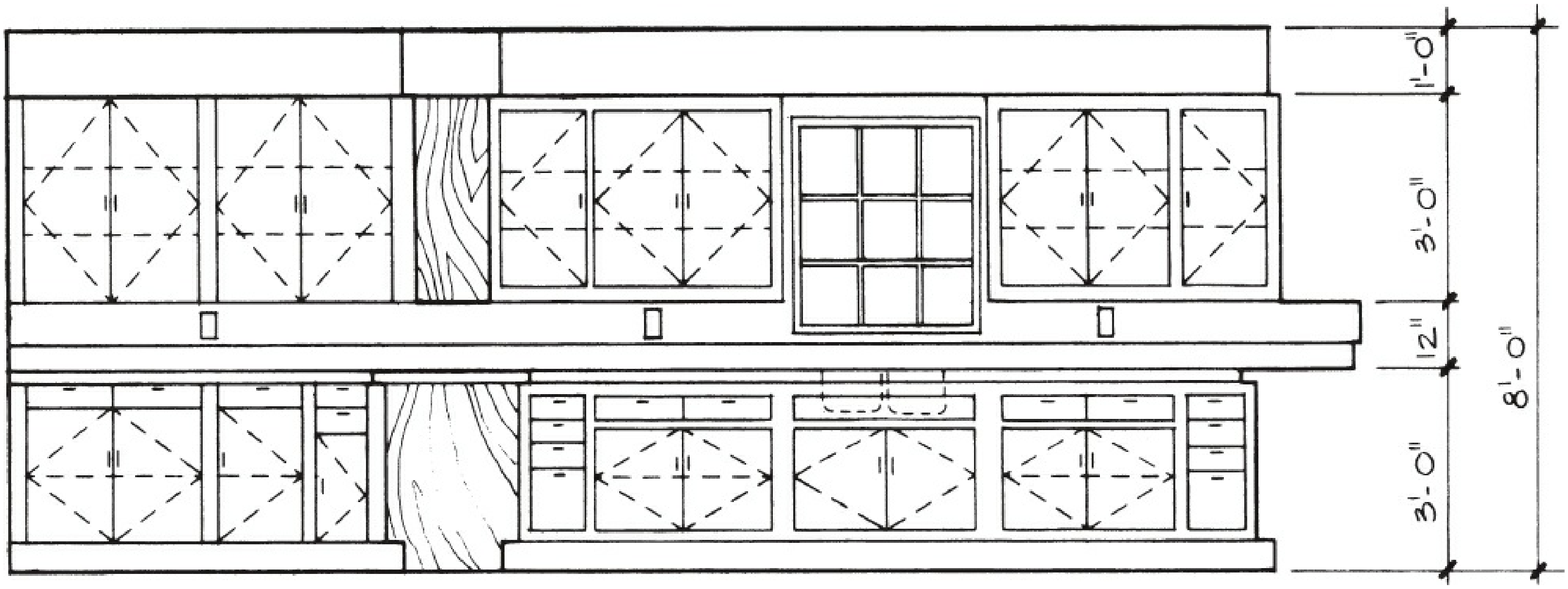


Figure 11.82 Interior elevation of Figure 11.80.

1. The difference in the method of representing a flush overlay and a lip door on the cabinets
2. The outlining of the cabinet on the extreme right side of the drawing
3. The use of dotted lines to show door swing, shelves, and the outline of the sink
4. The handling of the forward projection of the upper and base cabinets slightly to the left of center
5. Dimensions and, eventually, the location of notes

A Lobby and Restroom

Figure 11.83 shows a partial floor plan for the lobby and restroom area of an office building. Figure 11.84 shows the north elevation of the men's toilet. Because this is a public facility, access for persons with disabilities is shown on both the partial floor plan and the interior elevation.

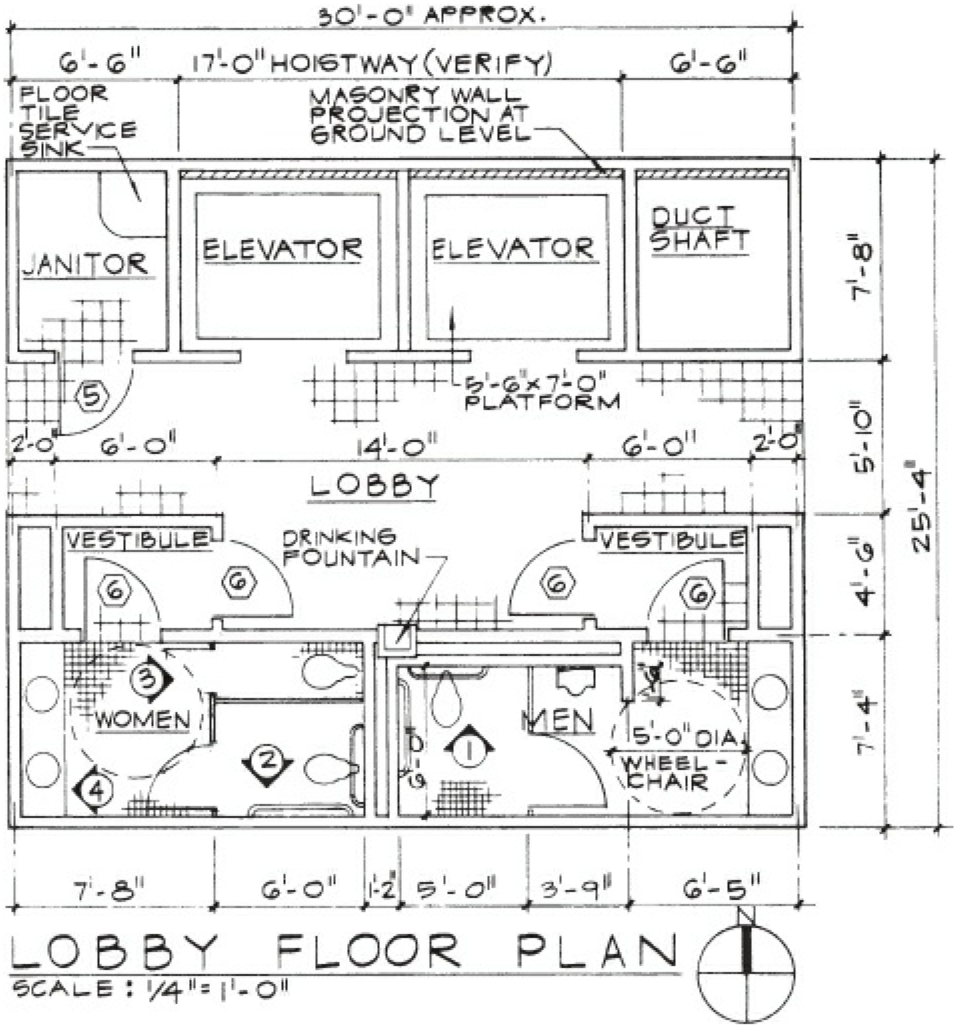


Figure 11.83 Partial floor plan of lobby and restroom.

(Courtesy of Westmount, Inc., Real Estate Development.)

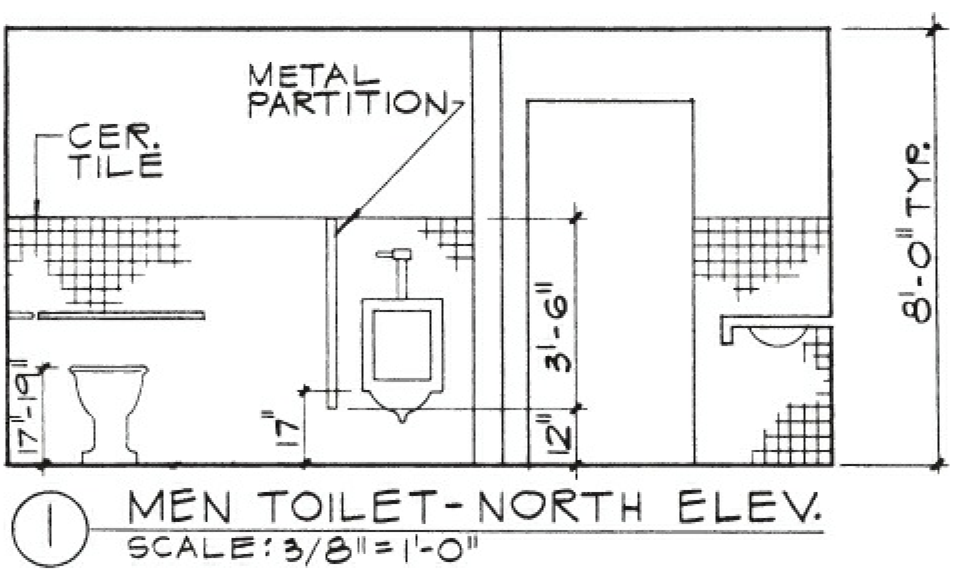


Figure 11.84 Men's toilet: North elevation.

(Courtesy of Westmount, Inc., Real Estate Development.)

COMPUTERS AND INTERIOR ELEVATIONS

The drafting of a set of interior elevations for any structure, be it commercial, industrial,

or residential, becomes a relatively painless task when you enlist the aid of a computer. Textures are easily applied to a drawing by using the appropriate commands. If you are drawing full scale in model space, you can transfer heights from the datum layer of the sections and the width and depth of a room from the floor plan.

Cabinet outlines, plumbing fixtures, and many other outlines can be imported from a set of previously developed drawings, or frequently can be found in a collection of shapes. A collection may include configurations and conventions for electrical, cabinetry, plumbing, and other categories, all stored in a library file of symbols and conventions.

The unique shapes of fireplaces, elevators, lifts, handrails, stairs, and so on can be purchased in a generic format, or exact sizes can be obtained from the manufacturers.

EVOLUTION OF A SET OF INTERIOR ELEVATIONS

This section is devoted to the various developmental stages of interior elevations. The Kavanaugh residence was selected to illustrate this. It has an exposed ridge and vaulted ceilings in some of its rooms, including the master suite, dining room, family room, library, kitchen, living room, and guest room. See Figure 11.75 and its accompanying text for a description of how to pictorially draw exposed beams in an interior elevation. The early stages of the floor plan are shown in Figure 11.85.

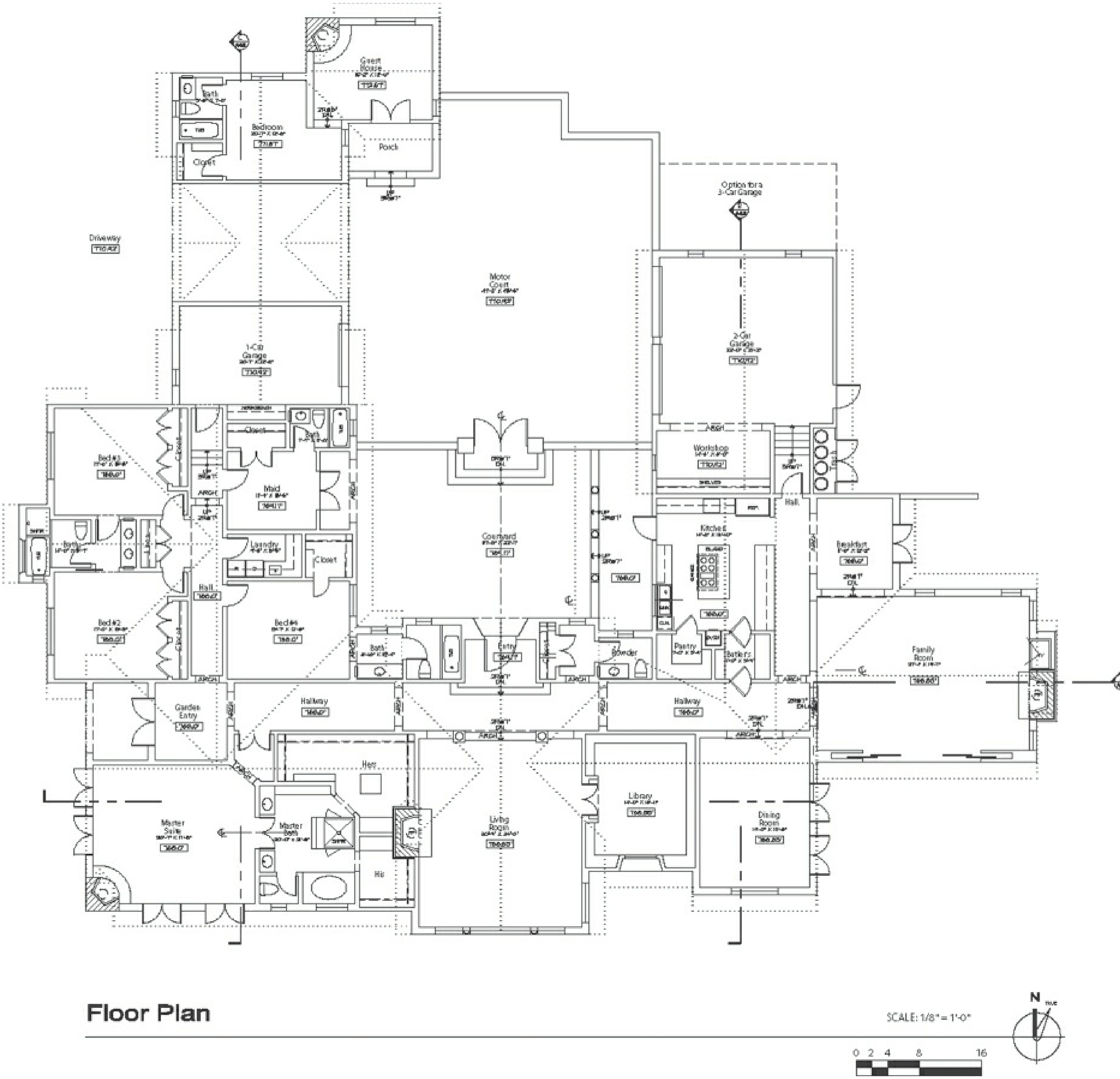


Figure 11.85 Reference floor plan.

(Courtesy of Kavanaugh Development.)

Stage I (Figure 11.86). Stage I, called the ***ease* or datum stage,** sets the parameters. These include the width from wall to wall and the height, and the changes that may occur in the floor or ceiling level. Before beginning this stage, the drafter should consult the project book and become familiar with the sizes and shapes of the various kitchen appliances, plumbing fixtures, cabinets, washer and dryer, and so forth.

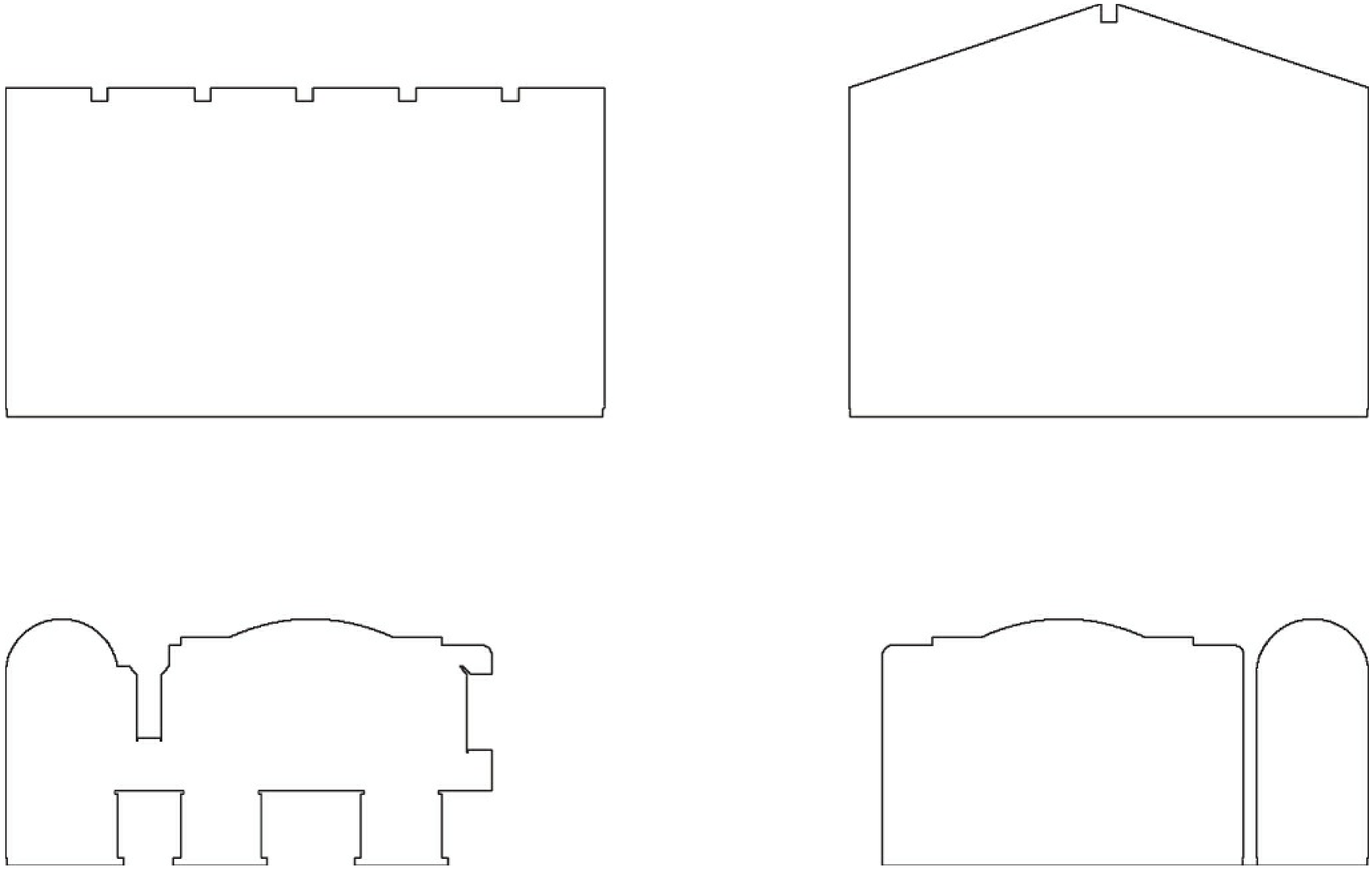


Figure 11.86 Stage I: Datum.

Stage II (Figure 11.87). Once the maximum size of the room is determined, the real outline of the interior elevation is established by drawing in the soffits, cabinets, fireplaces, and so on. Doors and windows may also be included in this stage. The total outline is now converted to a dark outline.

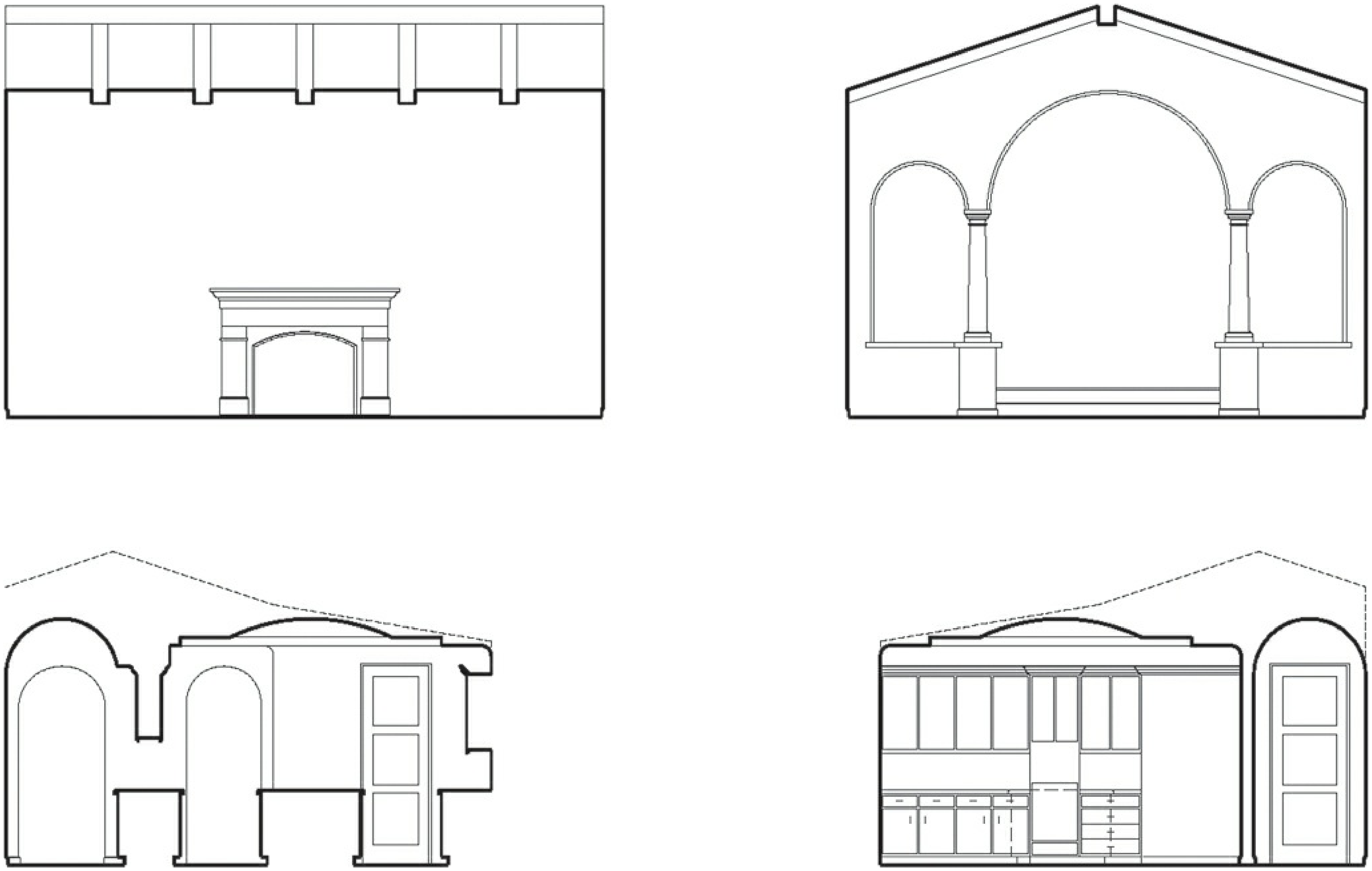


Figure 11.87 Stage II: Real outline and doors and windows.

Stage III (Figure 11.88). This is the stage at which various products are added to what is basically an empty room: bathtubs, toilets, built…in bookshelves, fireplaces, and so on.

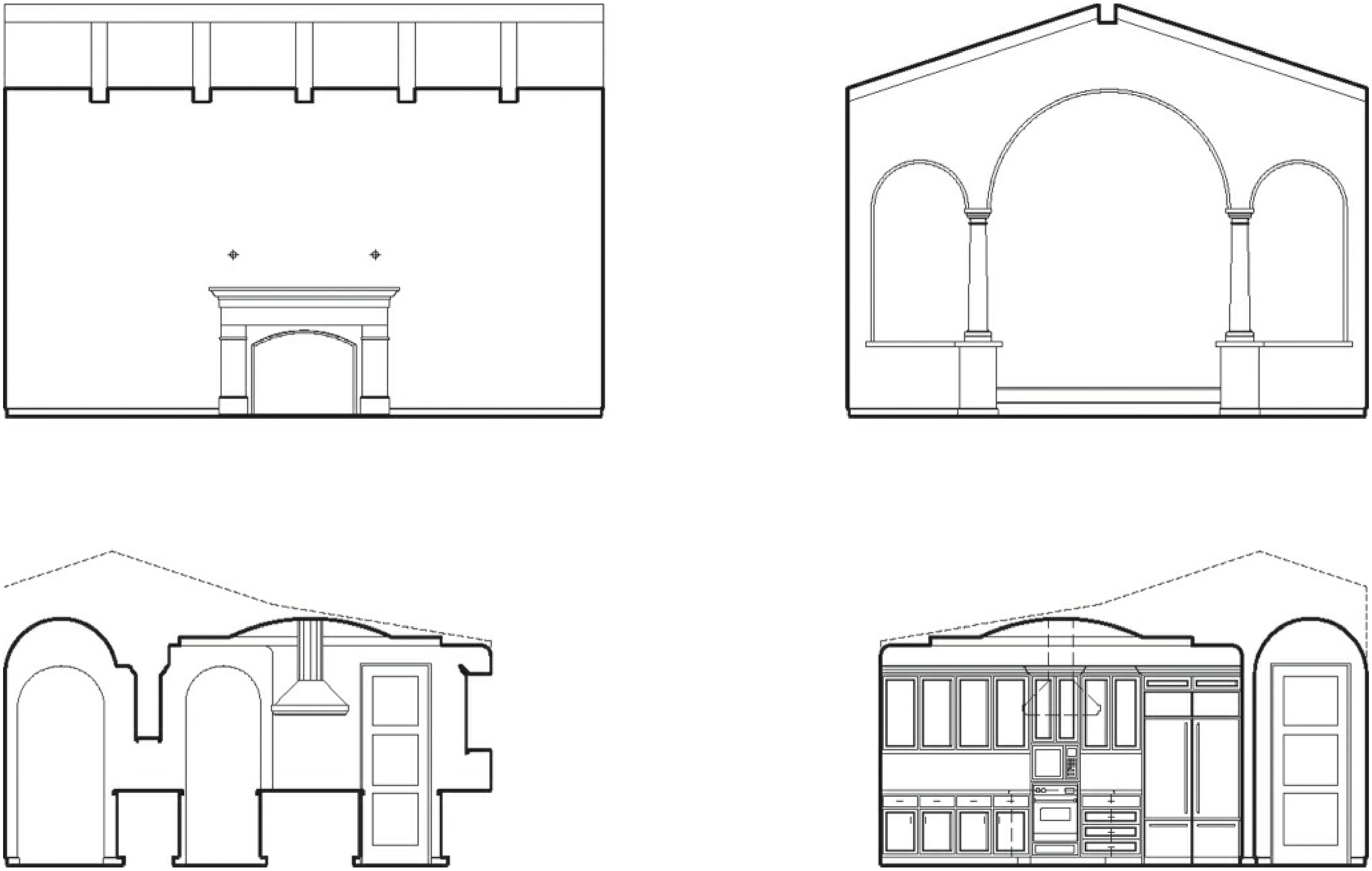


Figure 11.88 Stage III: Products and appliances.

Stage IV (Figure 11.89). Material designations and patterns, such as ceramic tile wainscots, fire extinguishers, bulletin boards, and decorative added forms, are included along with texturing. Some of the shapes for such items as plumbing fixtures can often be obtained from the manufacturer. Swings on cabinet doors and outlines (dotted) of fixtures behind the exposed face, such as a sink, flues from fireplaces, and shelves, are also added at this stage.

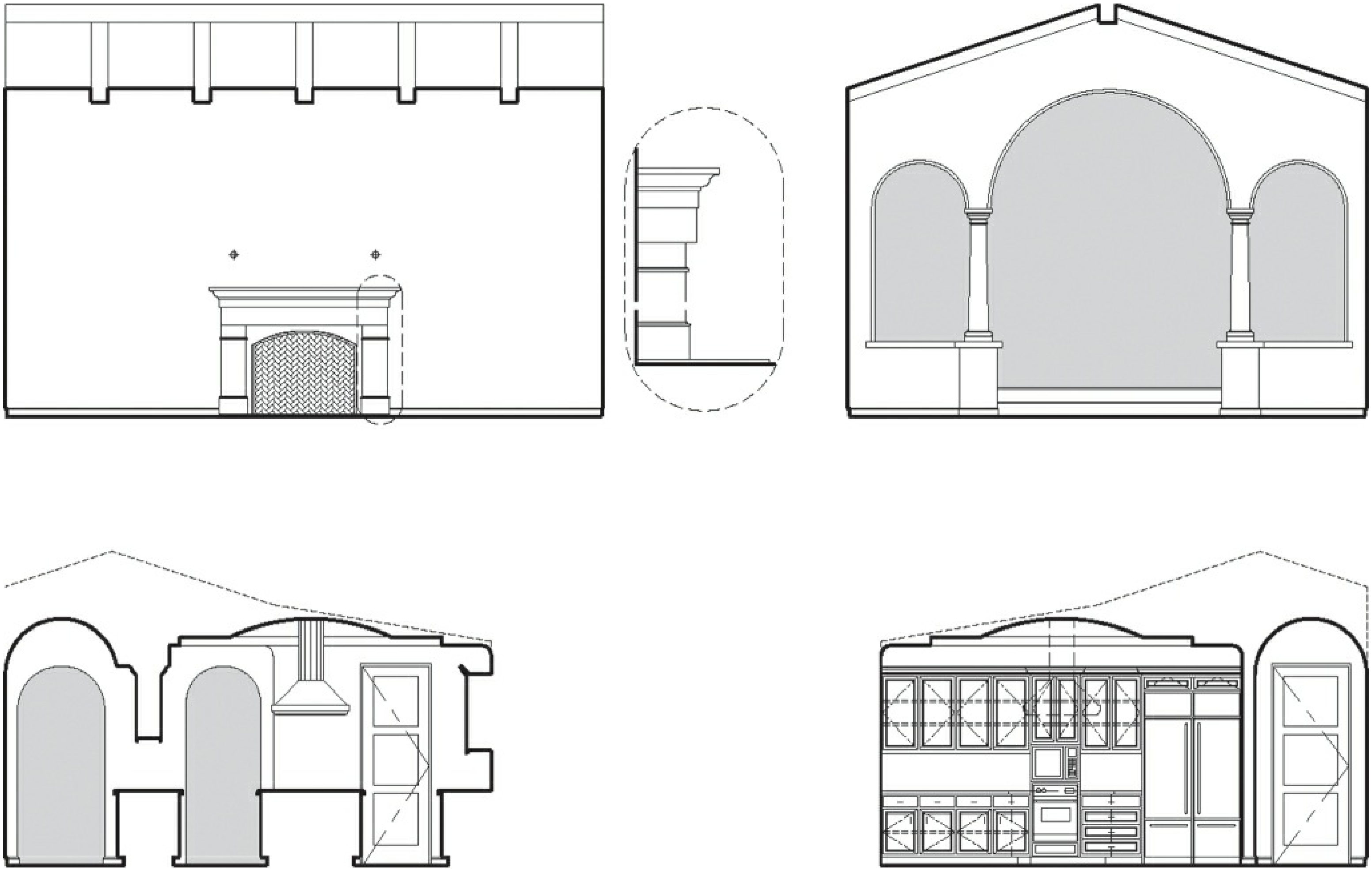


Figure 11.89 Stage IV: Material designation and patterns.

Stage V (Figure 11.90). This is the dimensioning stage. Remember, we must locate and size all items. A good example is a mirror. It must first be sized, and its placement or position on a wall must be given to the installer. If the installation is at all complex, a detail should be drawn. If a description is needed, the detailer must know whether the item is described in the specifications. If it is, a generic title is all that is needed at this stage. Dimensioning also calls for setting limits, such as the clearance of a water closet (toilet) between a wall and a cabinet. Some building codes require a minimum 15″ distance between the center of the water closet and the adjacent wall.

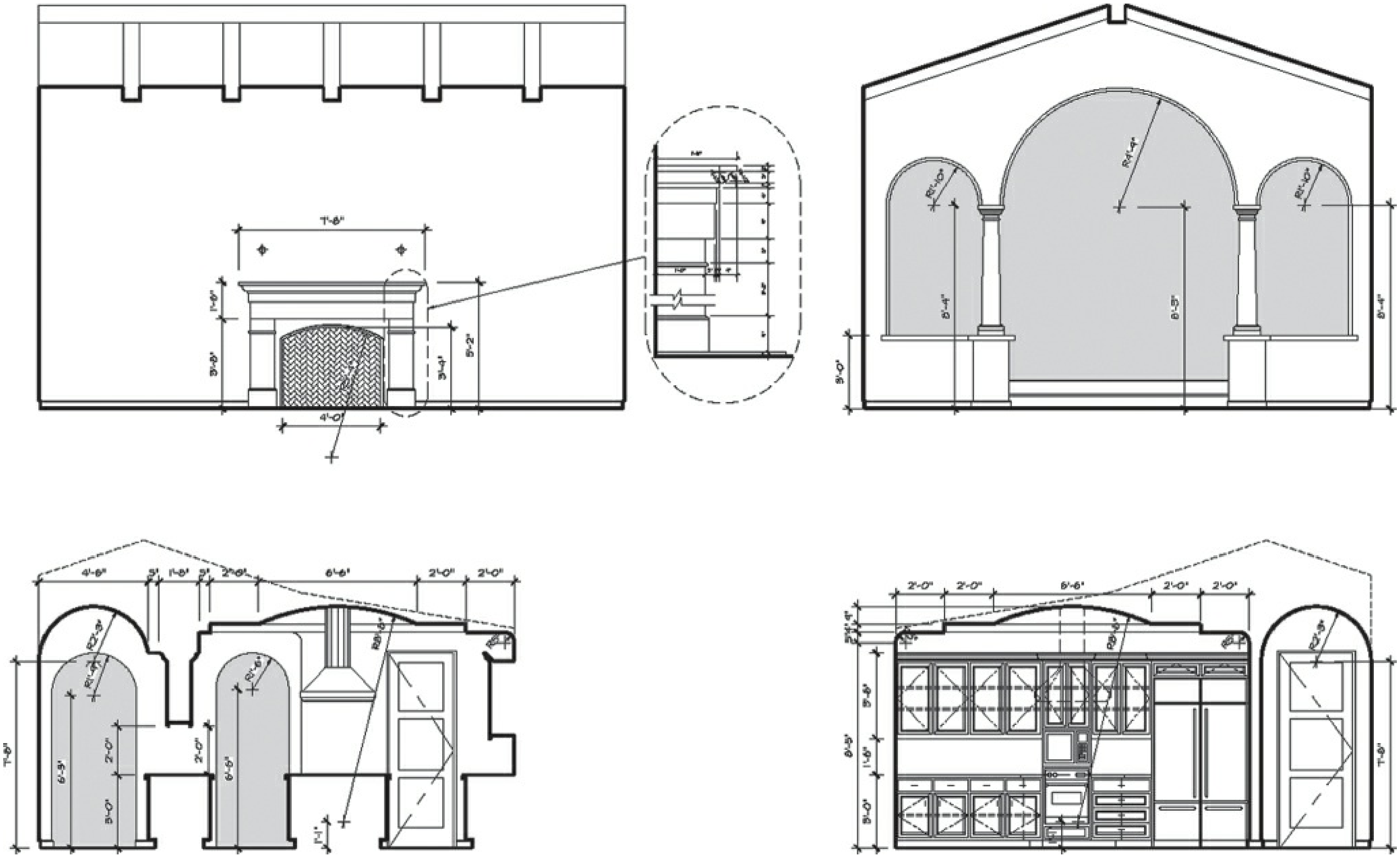


Figure 11.90 Stage V: Dimensioning.

Stage VI (Figure 11.91). Notes, references, and titles are included at this stage. Use the following checklist as a guide, or develop your own.

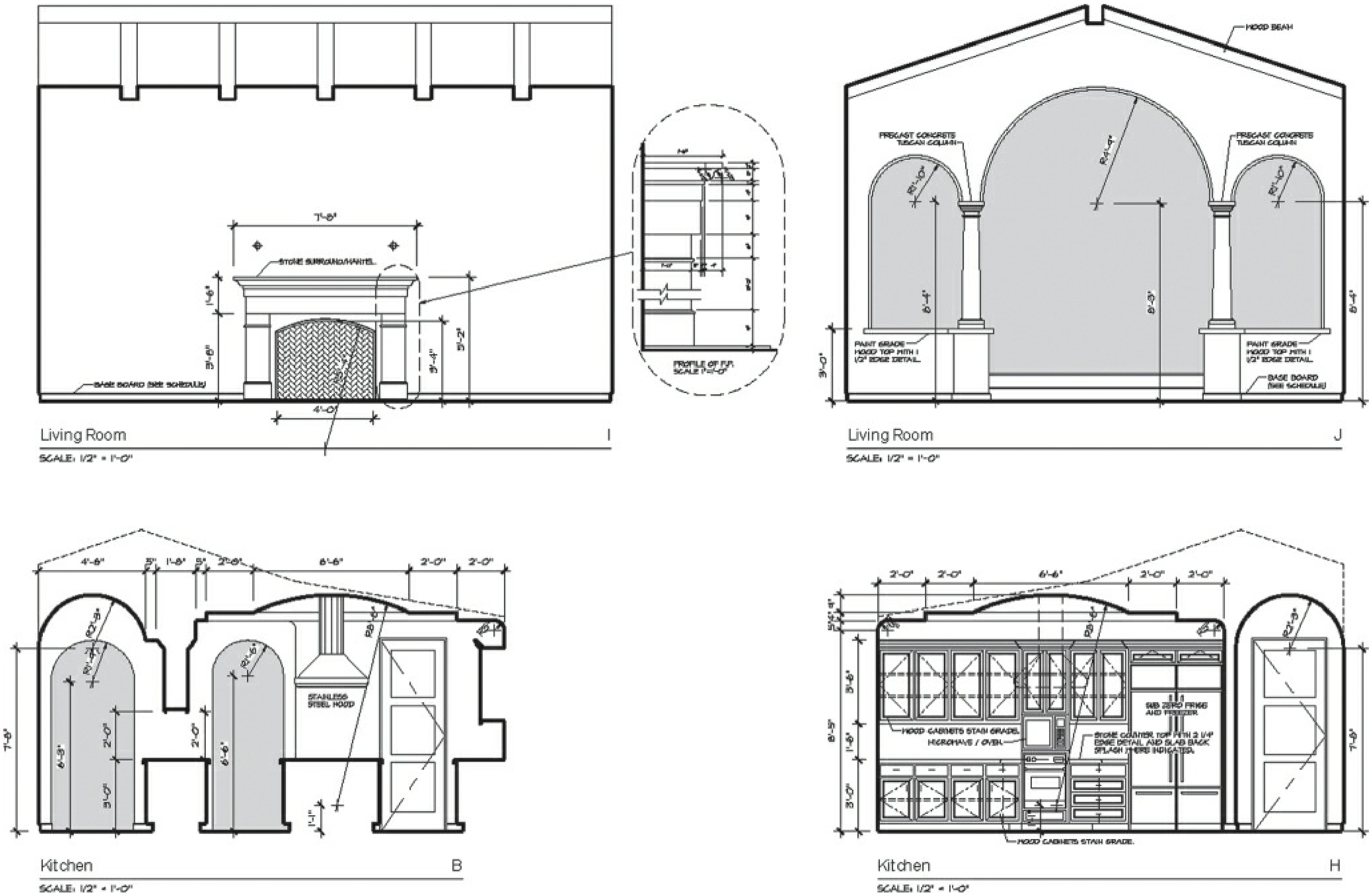


Figure 11.91 Stage VI: Noting, referencing, and titles.

(Courtesy of Kavanaugh Development.)

A. Call…outs for all surface materials, other than those included on the finish schedule.

B. A description of all appliances, even those that are not on the surface facing the observer: for example, sinks, garbage disposals, recessed medicine cabinets.

C. A description of items that are not standard. The open shelves in a master bedroom are a classic example.

D. The use of standard conventions to denote shelves, cabinet door swings, drawers, and so forth.

E. Any clearances that must be maintained; those needed for refrigerators and microwave ovens or any client…specific equipment.

Interior Elevations Using BIM

Because a three…dimensional model already has been produced when you are using building information modeling (BIM), the beginning form of the interior elevation already exists in a simplified pattern and is accessed via a pull…down menu (see Figure 11.53B). The drafter's job now is to complete the image, add detail, reference to existing details, do dimensioning when necessary, and note the materials used.

The pull‑down menu is used again to obtain the designed outline form of the interior elevation. Before you begin enhancement of the interior elevations, double‑check the existing datums, especially for the width and height of each room.

The objects that are closest to the viewer are dark. The objects farther away from the viewer are just a bit lighter, but still dark in relation to such things as doors, windows, dimensions, and so on. Remember, this is not just a technical drawing with standard line types; it is also a piece of artwork putting the design into visual images so that the craftspersons in the field can easily visualize their task.

The second stage is to put in the appliances and fixtures. In the third stage, you add material designations and patterns. Fourth is dimensioning as needed to help the craftsperson. Finally, you will add noting, referencing, and of course titles and scale.

When you look at some of the ornate structures built in the past, such as those shown in Figures 11.92 and 11.93, you might wonder how the actual construction document looked. Figure 11.92 is the entry to the performance and training center for the famous Lipizzaner stallions. Figure 11.93 is one of the interior spaces of the world‑famous Vienna State Opera (Wiener Staatsoper). Both are located in Vienna, Austria. In fact, elaborate concept sketches were developed by the artists who were commissioned to design these structures, and there was a well‑planned coordination between the sculptor and the artist. In some instances, small design models were constructed and sketches were drawn onto the elevations.

Figure 11.92 Lipizzaner training and performance structure, Vienna, Austria.

Figure 11.93 Vienna State Opera, Austria.

In the case of the Hearst castle, San Simeon, the designer, Julia Morgan, actually drew sketches onto the elevations, which were based on the already‐placed sculptures that had been collected by William Randolph Hearst, the great newspaper publisher.

Almost every U.S. resident—and many tourists—know about Disneyland in California. Across from Disneyland, there is still another Disney amusement park, called *California Adventure*. The centerpiece of this park is a man‐made 150‐foot‐high mountain. Atop this mountain sits a large “grizzly bear” rock formation (see Figure 11.94). How does one build such a large mountain, and especially the grizzly bear feature? This is where computers come into play. Miniature models were sculpted and 3‐D scanners were used to produce an exact digital image of the model, which was used to plan and draw the rebar structure needed to duplicate the exact shape of the models. Wire mesh and hand‐meshed concrete plaster were used to complete the effect.

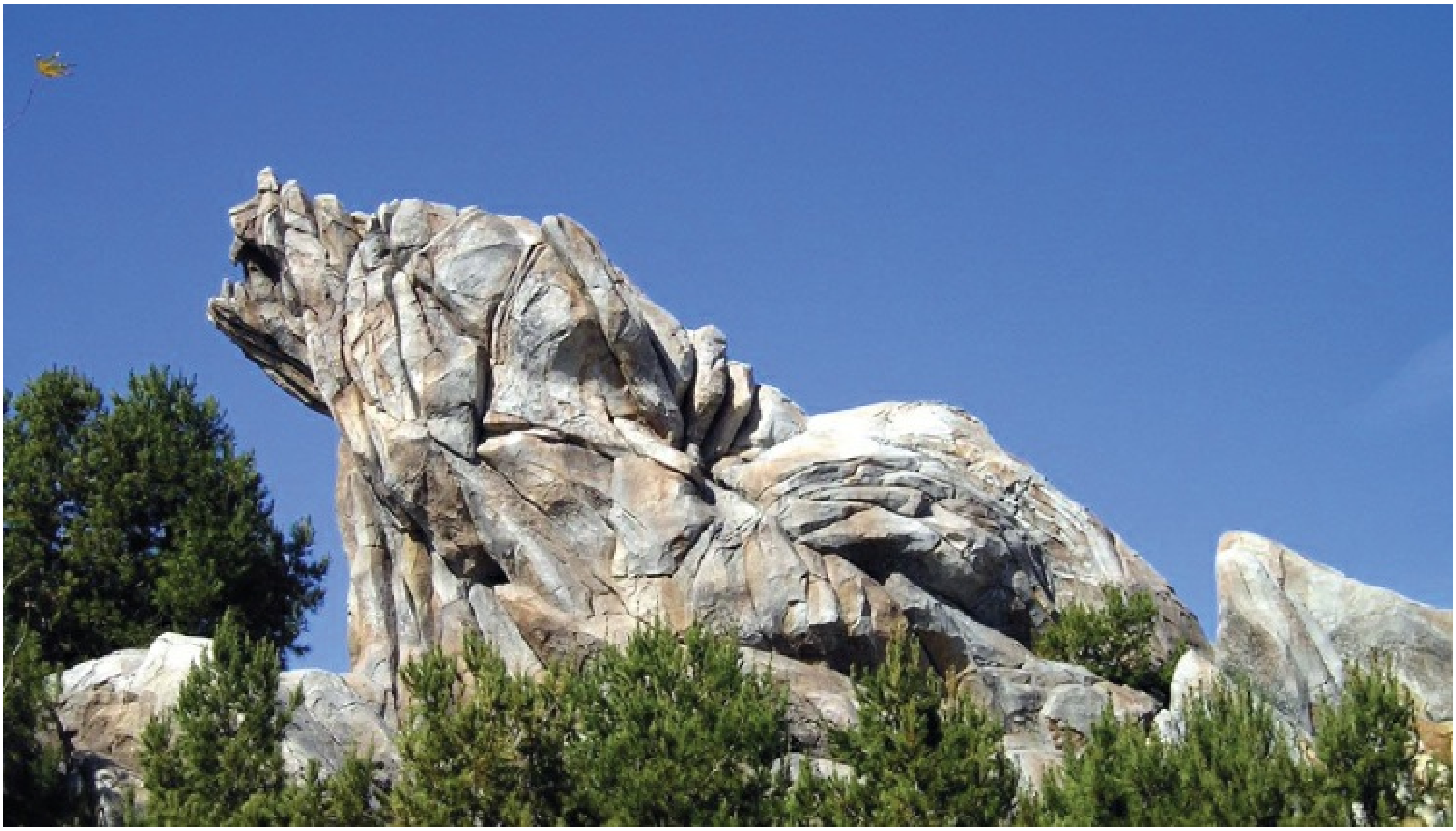


Figure 11.94 Disney theme park icon.

This technique was also used to complete the second rendition of the MGM lion in front of the MGM Grand Hotel in Las Vegas (shown in Figure 11.95). The lion, as every movie fan knows, is MGM's iconic trademark that opens each of its movies with a roar. Architects and designers alike depend on the computer and 3‐D scanners to produce large‐scale drawings from a desired model. For example, this enabled the designer to reproduce the lion structure by forming the steel framework to which wire mesh and hand‐meshed concrete plaster were applied.

Figure 11.95 MGM lion, Las Vegas, Nevada.

(Courtesy of CityCenter Land, LLC.)

The computer/scanner combination is a great partnership, making it possible to draw complex buildings and structures in three dimensions. Using BIM is a good example of turning 3…D drawings into workable and precise construction documents, via computer…aided design software, such as Revit.

CASE STUDIES: WORKING DRAWING DEVELOPMENT

In this section, we discuss the development of the interior elevations working drawings for the Clay Theater steel and masonry building (Chapter 18).

Clay Theater—Steel/Masonry Structure

Interior Elevations

Stage I

The partial floor plan shown in Figure 11.96 was drawn at a larger scale than the other plans. It includes the concession areas and restrooms. Only a few interior elevations are drafted here.

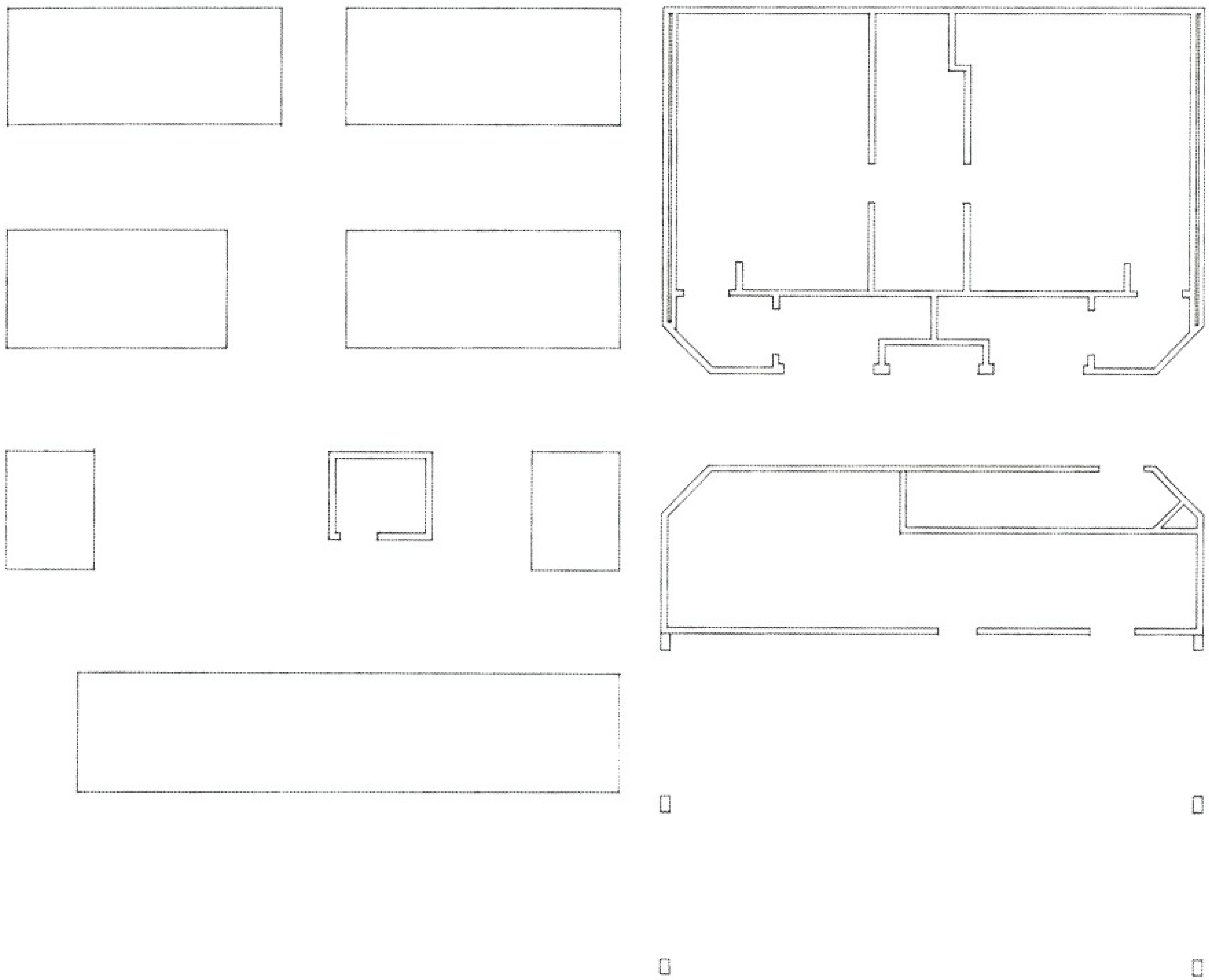


Figure 11.96 Clay Theater—Stage I Working drawings—interior elevations.

Here, the partial floor plan is drawn twice the size of the first…floor plan. We took the measurements from the first…floor plan. At this scale, we could also show the double wall for the plumbing. (See the wall with toilets.) The four rectangles at the bottom of the drawing represent columns. Two more columns appear to be located next to the walls but are actually inside the walls. They were included for visual continuity and have no structural implications. The left half of the drawing was blocked out to receive the interior elevations, with one exception: the floor plan of the toilet on the upper…floor level located slightly left of center on the drawing. The rectangle to the right of the upper floor toilet would become the interior elevation for that toilet, while the long rectangle at the bottom would become the interior elevation of the entry to the restrooms and telephone area.

Stage II

The partial floor plan now shows the plumbing fixtures and the floor material in the restrooms. See Figure 11.97. The rectangles at the center near the entry to the restrooms

are drinking fountains. Across the hall are the stairs to the upper level. The wall material was now added to the interior elevations. Various fixtures such as urinals, paper towel dispensers, grab bars for disabled persons, and drinking fountains were also added.

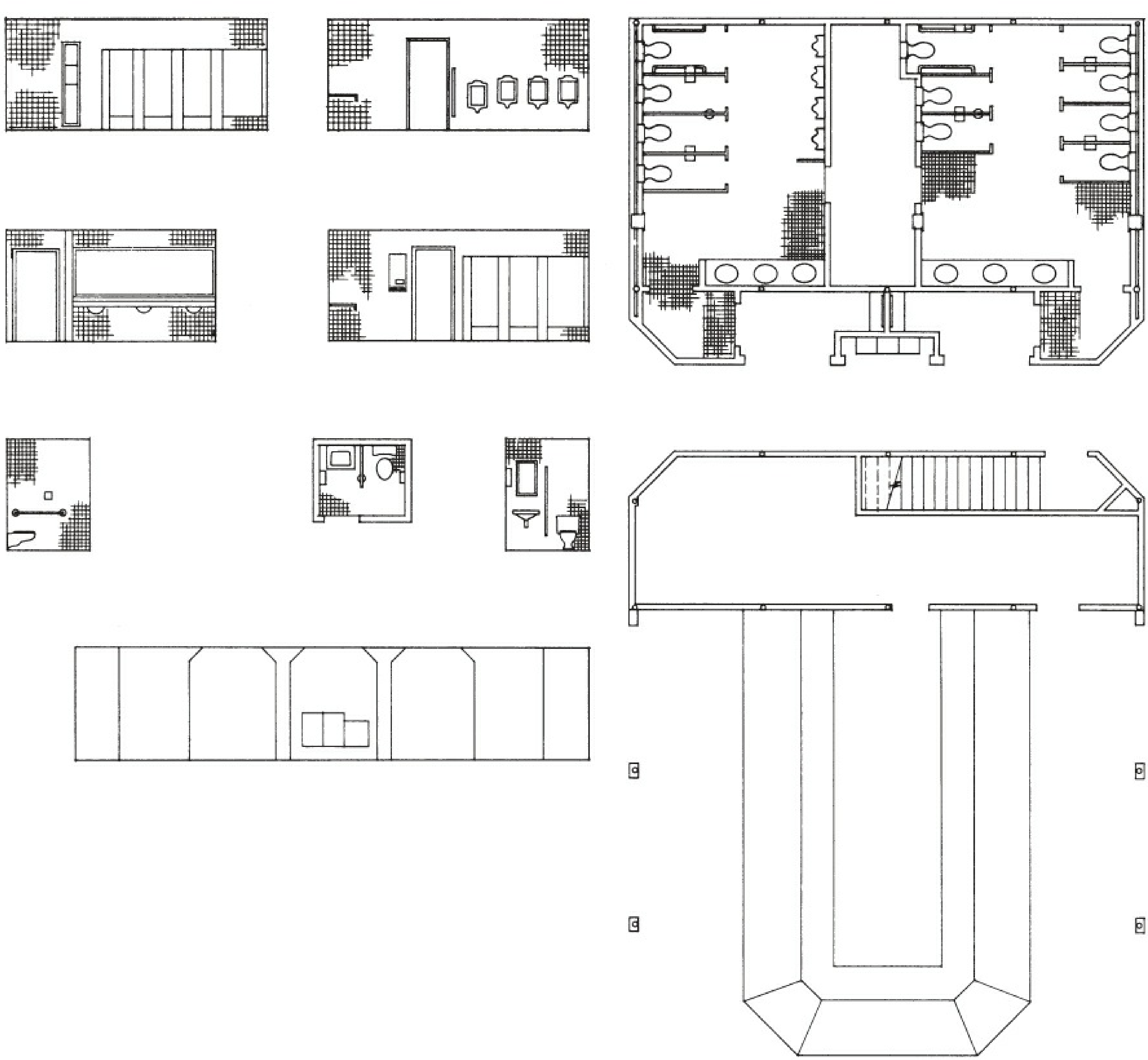


Figure 11.97 Clay Theater—Stage II Working drawings—interior elevations.

Stage III

All of the necessary dimension lines not included on the ground floor plan were located on this sheet (see Figure 11.98), as well as some of the critical dimensions on the interior elevations. Door swings were shown by dotted lines. We added the designation of floor material in the concession area.

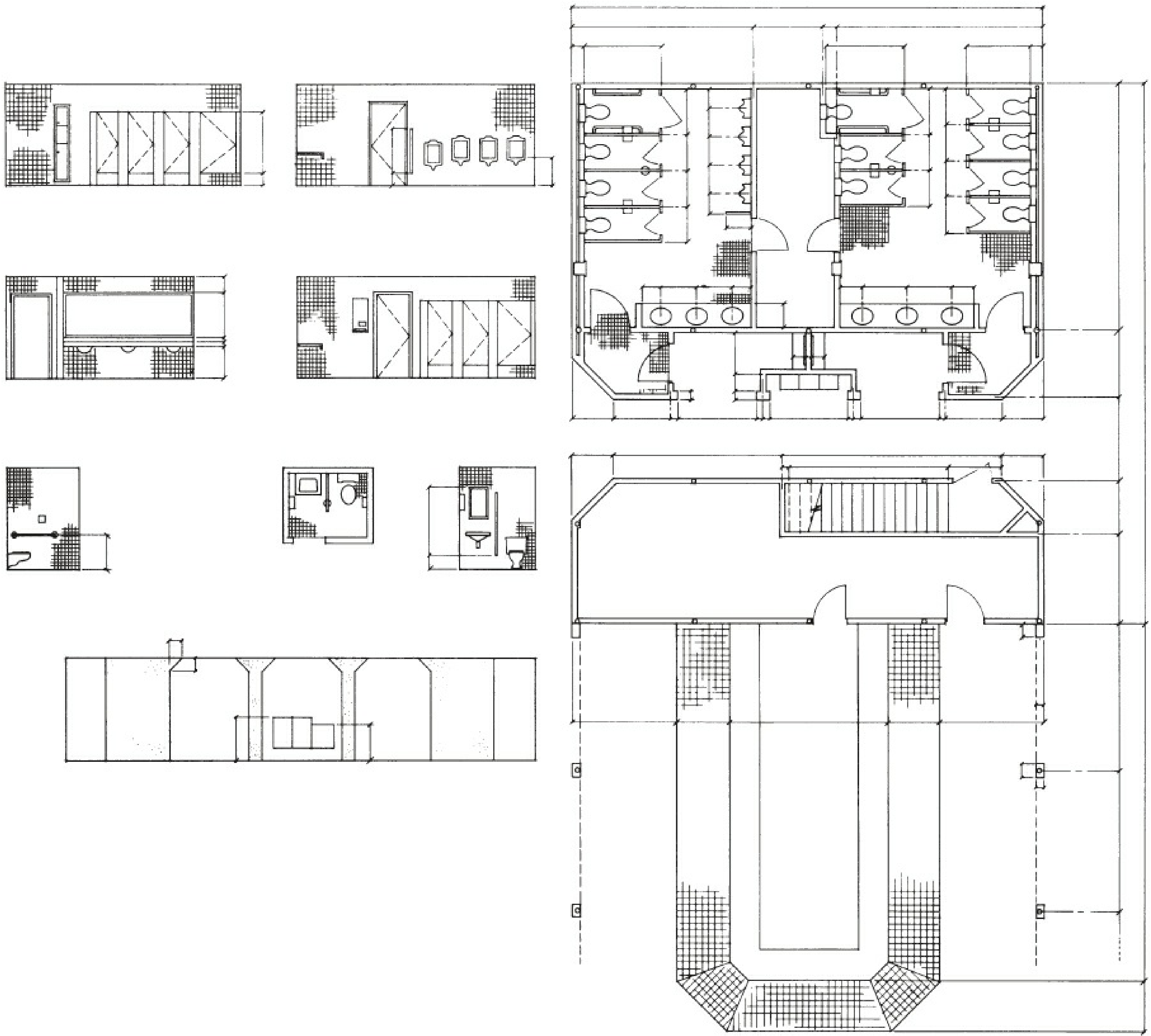


Figure 11.98 Clay Theater—Stage III Working drawings—interior elevations.

Key Terms

Eave

stepped footing

Chapter 12
SCHEDULES: DOOR, WINDOWS, AND FINISH

SCHEDULES DEFINED

A schedule is a list or catalog of information that defines the doors, windows, or finishes

of a room. The main purpose of incorporating schedules into a set of construction documents is to provide clarity, location, sizes, materials, and information for the designation of doors, windows, room finishes, plumbing and electrical fixtures, and other such items.

Schedules may be presented in tabulated or pictorial form. Although tabulated schedules in architectural offices vary in form and layout from office to office, the same primary information is provided.

Figures 12.1 and 12.2 are examples of tabulated door and window schedules. The door schedule provides a space for the symbol, the width and height, and the thickness of the door. It also indicates whether the door is to be **solid core (SC)** or **hollow core (HC)**. The “type” column may indicate that the door has raised decorative panels, a slab door, French door, and so forth.

DOOR SCHEDULE

KEY	WIDTH	HEIGHT	THICK.	TYPE	MATERIAL	GLAZING	REMARKS
1	16'-0"	7'-0"	1 3/4"	A	STAIN		ROLL-UP SECTIONAL GARAGE DOOR.
2	3'-6"	7'-0"	1 3/4"	B	PAINT GRD. WOOD		
3	2 - 2'-6"	7'-0"	1 3/4"	C		TEMP.	FRENCH DOORS
4	2 - 2'-6"	7'-0"	1 3/4"	C		TEMP.	FRENCH DOORS
5	2 - 2'-6"	7'-0"	1 3/4"	C		TEMP.	FRENCH DOORS
6	2 - 2'-6"	7'-0"	1 3/4"	C		TEMP.	FRENCH DOORS
7	2'-8"	7'-0"	1 3/4"	D	PAINT GRD. WOOD		
8	2'-8"	7'-0"	1 3/8"	D	PAINT GRD. WOOD		SELF-CLOSING, TIGHT FITTING 20 MINUTE RATED DOOR
9	2'-8"	7'-0"	1 3/8"	D	PAINT GRD. WOOD		
10	2 - 1'-4"	7'-0"	1 3/8"	D	PAINT GRD. WOOD		
11	2'-6"	7'-0"	1 3/8"	D	PAINT GRD. WOOD		
12	2'-6"	7'-0"	1 3/8"	D	PAINT GRD. WOOD		
13	2'-0"	7'-0"	1 3/8"	D	PAINT GRD. WOOD		
14	2'-6"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
15	2 - 2'-6"	8'-0"	1 3/8"	E	PAINT GRD. WOOD		BY-PASS
16	2'-8"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
17	2'-8"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
18	2 - 3'-6"	8'-0"	1 3/8"	E	PAINT GRD. WOOD		BY-PASS
19	2'-6"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
20	2'-6"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
21	2'-8"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
22	2 - 3'-0"	8'-0"	1 3/8"	E	PAINT GRD. WOOD		BY-PASS
23	2'-8"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
24	2 - 2'-6"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
25	2'-6"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
26	2'-6"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
27	2'-6"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		
28	2'-6"	8'-0"	1 3/8"	D	PAINT GRD. WOOD		

Figure 12.1 Door schedule.

WINDOW SCHEDULE							
KEY	WIDTH	HEIGHT	TYPE	MATERIAL	GLAZING	HEAD HGT. FROM F.F.	REMARKS
1	6'-0"	5'-6"	A	VINYL		7'-0"	SINGLE HUNG
2	2'-0"	5'-0"	B	VINYL		7'-0"	SINGLE HUNG
3	2'-0"	5'-0"	B	VINYL		7'-0"	SINGLE HUNG
4	6'-0"	5'-0"	A	VINYL		7'-0"	SINGLE HUNG
5	4'-0"	5'-0"	J	VINYL		7'-0"	SINGLE HUNG
6	4'-6"	5'-0"	J	VINYL		7'-0"	SINGLE HUNG
7	4'-0"	5'-0"	J	VINYL	TEMP.	7'-0"	SINGLE HUNG
8	2'-0"	5'-0"	B	VINYL	TEMP.	7'-0"	SINGLE HUNG
9	2'-0"	5'-0"	B	VINYL	TEMP.	7'-0"	SINGLE HUNG
10	6'-0"	5'-0"	A	VINYL		7'-0"	SINGLE HUNG. EGRESS
11	1-6"	3'-8"	E	VINYL	TEMP.	8'-0"	SINGLE HUNG
12	1'-9"	5'-6"	B	VINYL		8'-0"	SINGLE HUNG
13	3'-8"	5'-6"	F	VINYL		8'-0"	SINGLE HUNG
14	1'-9"	5'-6"	B	VINYL		8'-0"	SINGLE HUNG
15	2'-6"	5'-0"	G	VINYL		8'-0"	SINGLE HUNG. EGRESS
16	4'-0"	3'-8"	C	VINYL		8'-0"	SINGLE HUNG
17	6'-0"	5'-0"	A	VINYL		8'-0"	SINGLE HUNG. EGRESS
18	2'-0"	3'-8"	E	VINYL	TEMP.	8'-0"	SINGLE HUNG
19	2'-6"	5'-0"	G	VINYL	TEMP.	8'-0"	SINGLE HUNG. EGRESS
20	6'-0"	5'-0"	A	VINYL		8'-0"	SINGLE HUNG. EGRESS
21	3'-0"	5'-0"	D	VINYL		8'-0"	SINGLE HUNG
22	1'-9"	5'-6"	B	VINYL		7'-0"	SINGLE HUNG
23	3'-8"	5'-6"	F	VINYL		7'-0"	SINGLE HUNG
24	1'-9"	5'-6"	B	VINYL		7'-0"	SINGLE HUNG
25	2'-6"	5'-0"	G	VINYL		8'-0"	SINGLE HUNG. EGRESS
26	2'-6"	5'-0"	G	VINYL		8'-0"	SINGLE HUNG. EGRESS
27	5'-0"	3'-8"	H	VINYL	TEMP.	8'-0"	SINGLE HUNG
28	3'-0"	3'-8"	I	VINYL	TEMP.	8'-0"	SINGLE HUNG
29	3'-0"	3'-8"	I	VINYL	TEMP.	8'-0"	SINGLE HUNG
30	3'-6"	3'-6"					SKYLIGHT
31	3'-6"	3'-6"					SKYLIGHT

Figure 12.2 Window schedule.

The material space may indicate what type of material is to be used, it could be vinyl, aluminum, wood, or composite. If wood is to be used for the door, such as birch or beech, and if it is paint…grade or stain…grade quality. Space for remarks is used to provide information, such as the closing device or hardware to be used, or the fire rating required for the door. In some cases, where there is insufficient space for remarks, an asterisk (*) or symbol number may be placed to the left of the schedule or in the designated box and referenced to the bottom of the schedule with the required information. Information must under no circumstances be crowded or left out. For any type of schedule that includes lettering, provide sufficient space in each frame so that your lettering is not cramped or unclear.

Symbol designations for doors and windows vary in architectural offices and are influenced by each office's procedures. For example, a circle, a hexagon, or a square may be used for all or part of the various schedules; these are the most commonly used. Typically, we do not use triangles, as these symbols are used for revision numbers or for shear walls. Figure 12.3 illustrates symbol shapes and how they may be shown. There are various options, such as using a letter or number, or both, and various shapes. Door and window symbol shapes should be different from each other. To clarify reading the floor

plan, the letter “D” at the top of the door symbol and the letter “W” at the top of the window symbol are used. The letter “P” is used for plumbing fixtures, “E” for electrical fixtures, and “A” for appliances. Place the letter in the top part of the symbol. Whatever symbol shape you select, be sure to make the symbol large enough to accommodate the lettering that will go inside the symbol shape.

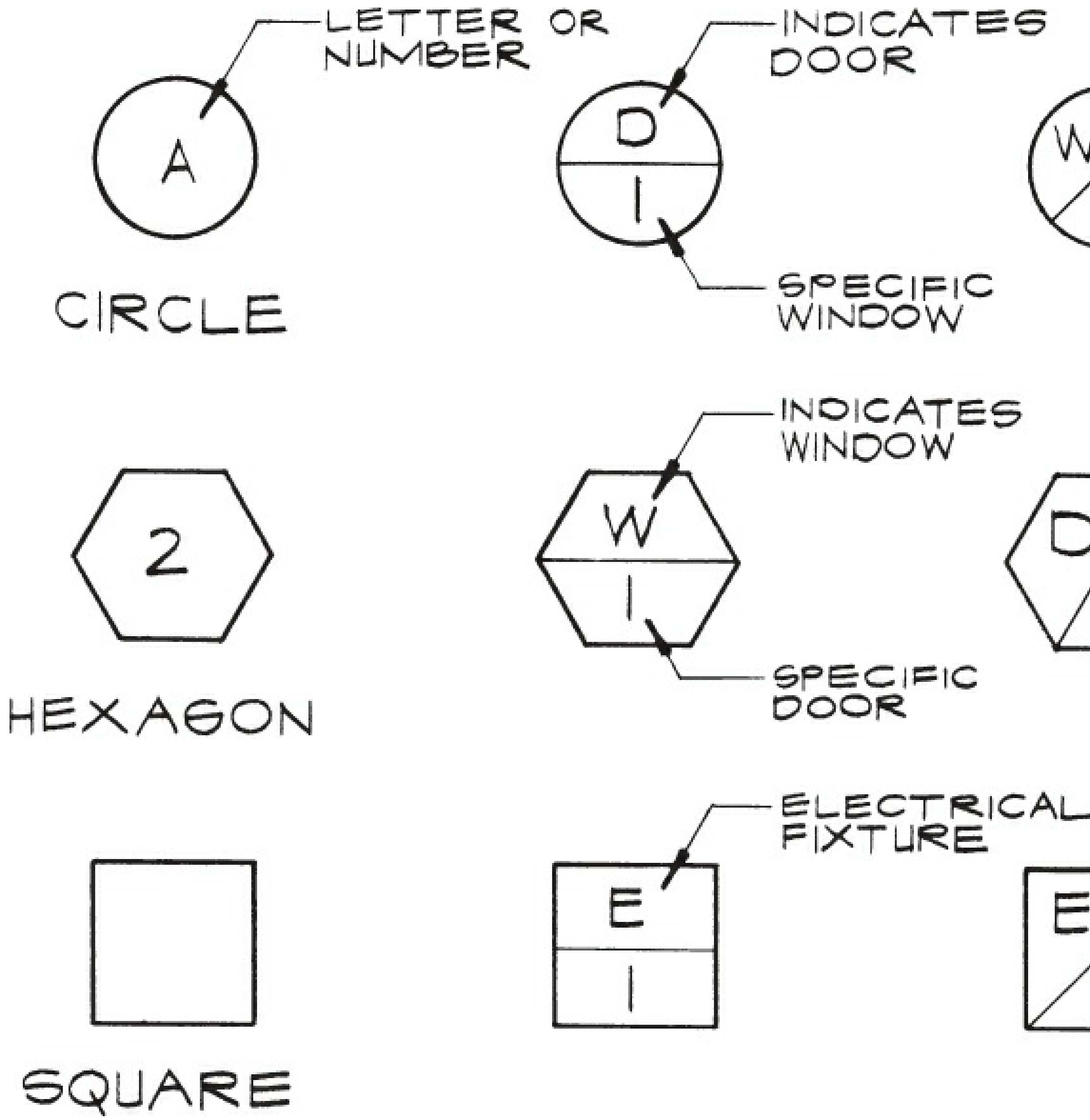


Figure 12.3 Symbol designations.

When you provide lines for the anticipated number of symbols to be used, allow extra spaces for door and windows that may be added as the project develops and evolves.

Your specific choice of a tabulated schedule may involve the following factors:

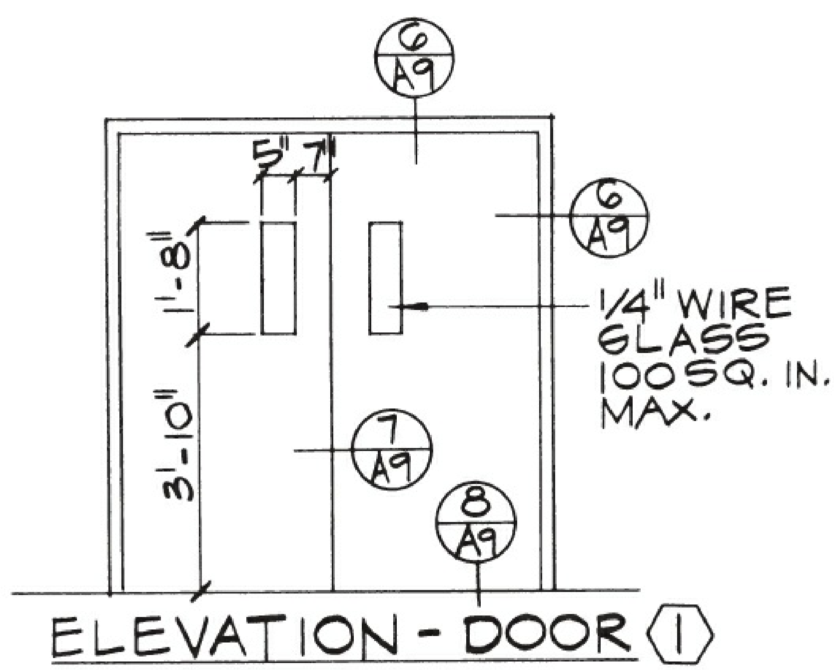
- Specific office procedures
- Standardization or variety of doors and windows selected
- Items with different dimensions
- Ease of changing specifications
- Format layout on plot pages

- Repetition of call…outs

PICTORIAL SCHEDULES: DOORS AND WINDOWS

In many cases, tabulated schedules cannot clearly define a specific door or window. In this case, you can add to a schedule a reference with a pictorial drawing of a door or window adjacent to the schedule, as shown in [Figure 12.4](). Door 1 is difficult to explain, so a pictorial representation makes it clearer.

DOOR SCHEDULE							
SYM.	WIDTH	HEIGHT	THK.	HC/SC	TYPE	MATERIAL	REMARKS
1	PR.3'-2"	7'-0"	1 3/4"	HC	N L	STEEL	1-HR. SELF CLOSING, PANIC HDW.
2	3'-0"	"	"	"	FLUSH	"	" " " NO GLASS
3	"	"	"	SC	SLAB	WOOD	
4	"	6'-8"	"	"	"	"	1-HR, SELF CLOSING, MTL. JAMBS
5	"	"	"	"	"	"	
6	"	"	"	"	"	"	SELF CLOSING, PUSH PLATES



[Figure 12.4]() Pictorial representation on a tabular schedule.

A **pictorial schedule**, as distinct from a pictorial representation, is totally pictorial. Each item is dimensioned and accompanied by data such as material, type, and so forth. [Figure 12.5]() shows a pictorial schedule of a window. A pictorial schedule provides section references for the **head**, **jamb**, and **sill** sections, so you no longer need to reference the exterior elevations. (The *head* is the top of a window or door, *jamb* refers to the sides of a window or door, and the *sill* is the bottom of the window.)

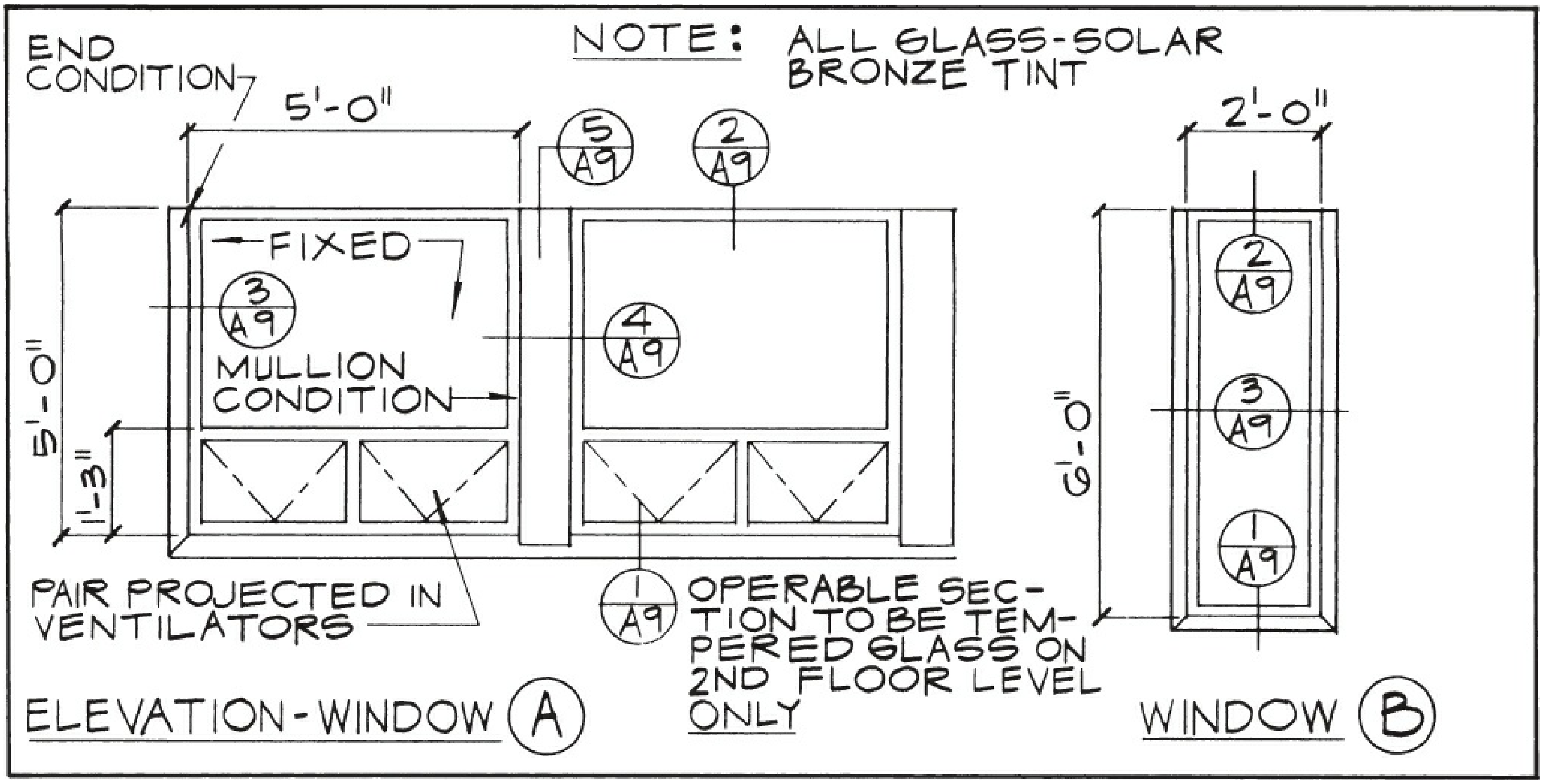


Figure 12.5 Pictorial schedule.

Choice of a pictorial schedule may involve the following factors:

- Specific office procedures
- Unusual and intricate door or window design requirements
- Very few doors and windows in the project, or very few types used
- Desired clarity for window section referencing
- Irregular shapes
- Mixing types and shapes within a specific assembly

INTERIOR FINISH SCHEDULES

Interior finish schedules provide information such as floor and wall material, trim material, and ceiling finish. The layout of an interior finish schedule varies from office to office because of prevailing office philosophy and specific information the firm receives for various types of projects.

Figures 12.6 and 12.7 show interior finish schedules. The column allocated for room designation may show the room name or an assigned space number or both. Commercial buildings typically utilize room numbers, as many room names may be duplicated. Imagine a school or multistory building where classrooms or office spaces are utilized in repetition. This selection may be dictated by the project itself. Another method of defining finishes combines the room finish schedule with a room finish key, which uses numbers and letters to indicate the various materials to be used for floors, walls, and so forth. An

example of this type of schedule is shown in Figure 12.8. Using space numbers is more logical for a large office building, for example, than for a very small residence. Once again, when extensive information is required in the remarks section of the schedule, use an asterisk (*) or footnote number for reference at the bottom of the schedule.

INTERIOR FINISH SCHEDULE

ROOM	FLOOR					BASE						WALLS						CEILINGS							CABINETS				PAINT AND STAIN																	REMARKS
																													WALLS					CEILING				TRIM				CABINET				
	CARPET	HARDWOOD	STONE TILE	CERAMIC TILE	CONCRETE	PAINT GRADE 8" BASE	PAINT GRADE 5" BASE	STAIN GRADE 8" BASE	STONE	CERAMIC TILE	NONE	5/8" GYP. BD.	5/8" TYPE "X" GYP. BD.	WAINSCOT	STAIN-GRADE WOOD PANELING	BACK SPLASH CERAMIC TILE	CEMENT PLASTER	5/8" GYP. BD.	5/8" TYPE "X" GYP. BD.	STAIN GRD. T&G AND BEAMS	STAIN GRD. WOOD BEAMS/PLAST.	CEMENT PLASTER	RED BRICK	CROWN MOLDING	WOOD	STAIN GRADE ALDER	PAINT GRADE	MELAMINE	PAINT	ENAMEL	FAUX FINISH	WALL PAPER		PAINT	ENAMEL	STAIN	NOT APPLICABLE	PAINT	ENAMEL	STAIN		PAINT #	ENAMEL	STAIN #		
ENTRY																																													
LIVING RM.																																													
PWDR.																																													
DINING RM.																																													
KITCHEN																																													
NOOK																																													
FAMILY RM.																																													
MAST. BDRM.																																													
MAST. BATH																																													
BDRM. #2																																													
BATH #2																																													
BDRM. #3																																													
BATH #3																																													
BDRM. #4																																													
BATH #4																																													
BDRM. #5																																													
BATH #5																																													
LAUNDRY ROOM																																													
SITTING AREA																																													
GARAGE																																													

Figure 12.6 Interior finish schedule.

INTERIOR FINISH SCHEDULE

ROOM	FLOOR					BASE						WALLS						CEILING						CABINET				PAINT AND STAIN																	REMARKS
																												WALLS					CEILING				TRIM				CABINET				
	CARPET	HARDWOOD	MARBLE	CERAMIC TILE	CONCRETE	PAINT GRADE 2 1/4" BASE	STAIN GRADE 4" BASE	MARBLE	STONE	CERAMIC TILE	NONE	5/8" GYP. BD.	5/8" TYPE "X" GYP. BD.	WAINSCOT	STAIN-GRADE WOOD PANELING	FULL-HEIGHT CERAMIC TILE	CEMENT PLASTER	5/8" GYP. BD.	5/8" TYPE "X" GYP. BD.	STAIN GRD. T&G AND BEAMS	STAIN GRD. WOOD BEAMS/PLAST.	CEMENT PLASTER	RED BRICK	STAIN GRADE SOLID WOOD	PAINT GRADE	MELAMINE		PAINT	ENAMEL	FAUX FINISH	WALL PAPER		PAINT	ENAMEL	STAIN	NOT APPLICABLE	PAINT	ENAMEL	STAIN		PAINT #	ENAMEL	STAIN #		
B01 MECHANICAL ROOM																																													
B02 CONFERENCE ROOM																																													
B03 CONFERENCE ROOM																																													
B04 HALL																																													
B05 EXISTING LOBBY	NO WORK																																												
B06 EXISTING OFFICE	NO WORK																																												
B07 COPY ROOM																																													
B08 EXISTING OFFICE	NO WORK																																												
B09 EXSITING OFFICE	NO WORK																																												
B10 EXISTING CORRIDOR	NO WORK																																												
B11 EXISTING OFFICE	NO WORK																																												
B12 EXISTING OFFICE	NO WORK																																												
B13 EXISTING RESTROOM	NO WORK																																												
B14 EXISTING CHIOR ROOM	NO WORK																																												
B15 OFFICE																																													
B16 KITCHEN																																													
B17 EXISTING CORRIDOR	NO WORK																																												
B18 MULTI-PURPOSE ROOM																																													
B19 STORAGE																																													
B20 WOMEN'S																																													
B21 MEN'S																																													
B22 HALL																																													
B23 EXISTING JANITOR	NO WORK																																												
B24 STORAGE																																													
B25 EXISTING NURSERY RROM																																													
B26 OFFICE																																													
B27 EXISTING CRIB ROOM	NO WORK																																												
B28 EXISTING RESTROOM	NO WORK																																												
B29 EXISTING MECHANICAL ROOM	NO WORK																																												

Figure 12.7 Interior finish schedule.

ROOM FINISH SCHEDULE								
NO.	ROOM	FINISHES				CEIL. HGT.	ROOM AREA	REMARKS
		FLOOR	BASE	WALLS	CEILING			
101	RECEPTION	B	1	A	2	9'-0"	110□'	
102	OFFICE	A		B	2	8'-0"	170□'	
103	OFFICE	A		B	2	"	180□'	
104	OFFICE	A		B	2	"	185□'	
105	WOMENS TOIL.	C	1	A	1	7'-6"	30□'	
106	MENS TOILET	C	1	A	1	7'-6"	25□'	

ROOM FINISH KEY							
FLOORS		BASES		WALLS		CEILINGS	
A	CARPET	1	WOOD	A	5/8" SHEETROCK	1	5/8" SHEETROCK
B	OAK PARQUET			B	1x6 T&G CEDAR	2	SUSP. AC. TILE
C	CERAMIC TILE						

Figure 12.8 Room finish schedule—key type.

ADDITIONAL SCHEDULES

There are other forms of schedules that can be utilized to established clarity on a project. For example, if a project has many types of plumbing and appliance fixtures in various areas, provide additional schedules to clarify and to locate items with their designated symbols.

Figure 12.9 shows a plumbing fixture schedule, and Figure 12.10 shows an appliance schedule. This is an alternative method of identifying the fixtures and appliances that are required for a specific project scope. If these types of schedules are not used in a project, the fixture types, manufacturers, catalog numbers, and other information needed must be included in the project specifications.

FIXTURE SCHEDULE				
SYMB.	EQUIPMENT DEASCRIPTION	MOUNTING LOCATION	MFR / MODEL NO.	FIN NOTES
1	WATER CLOSET FLUSH VALVE	SURFACE / FLOOR	AMERICAN STD 3043.102	WHITE
2	URINAL FLUSH VALVE	SURFACE / WALL	AMERICAN STD 6541.132	WHITE
3	LAVATORY (SEE 8/501) (SELF-RIMMED)	SURFACE / COUNTERTOP	AMERICAN STD 0410.021	WHITE
4	FLUSH VALVE		SLOAN OPTIMA	CHROME
5	FAUCET	CENTER SET	SLOAN OPTIMA	CHROME

ACCESSORY SCHEDULE				
SYMB.	EQUIPMENT DESCRIPTION	MOUNTING LOCATION	MFR / MODEL NO.	FIN NOTES
1	PAPER TOWEL DISPENSER	SURFACE / WALL	BRADLEY 237-11	STAINLESS STEEL
2	SOAP DISPENSER	SURFACE / COUNTERTOP	BRADLEY 6326-68	STAINLESS STEEL
3	PAPER TOWEL DISPENSER	SEMI-RECESS WALL	BRADLEY 237-10	STAINLESS STEEL
4	SANITARY NAPKIN/ TAMPON DISPENSER	SURFACE/ WALL	BRADLEY 426-FREE	STAINLESS STEEL
5	1 1/4" DIA. GRAB BAR (SEE DTL. 9/501)	SURFACE / WALL	BRADLEY 812-7	STAINLESS STEEL
6	TOILET SEAT COVER DISPENSER	SURFACE/ WALL	BRADLEY 583	STAINLESS STEEL
7	TOILET TISSUE DISPENSER	SURFACE/ WALL	BRADLEY 5402	STAINLESS STEEL
8	SANITARY NAPKIN DISPOSAL	SURFACE/ WALL	BRADLEY 4722-15	STAINLESS STEEL
19	GEOMETRIC HC SYMBOLS (SEE DETAIL 3/501)	SURFACE/ WALL		PLASTIC
20	ACCESSIBLE RESTROOM SIGN (SEE DETAIL 1/501)	SURFACE/ WALL		PLASTIC

Figure 12.9 Plumbing fixture schedule.

APPLIANCE SCHEDULE				
SYM.	ITEM	MANUFACTURER	CATALOG NO.	REMARKS
1	COOKTOP	APPLIANCES INC.	RU38V	WHITE
2	MICROWAVE	"	JKP65G	
3	DISHWASHER	"	GSD2500	WHITE
4	DISPOSER	"	GFC510	

Figure 12.10 Appliance fixture schedule.

For most projects, the specifications will augment information found in the schedules. Examples of information usually found in the specifications include the window

manufacturer, the type and manufacturer of the door hardware, and the type and manufacturer of paint for the trim.

STRUCTURAL SCHEDULES

For building projects that may require various structural components, such as shear walls resisting lateral forces or spread concrete footings of various sizes carrying different loads, it is good practice to provide schedules for the various structural entities so as to maintain clear drawings.

Figure 12.11 is an example of a shear wall finish schedule. This schedule and the various finishes reflect the need for this kind of schedule to provide clarity when reviewing the structural drawings. A partial lateral floor plan is shown in Figure 12.12 to illustrate how shear walls are drawn.

Shear Wall Finish Schedule

Sym	Wall Material	Blocked / Unblocked	Nailing Size & Spacing	Stud Size	Anchor Bolts & Number	Remarks
S 1	1/2" GYPSUM WALLBOARD	UNBLOCKED	5d COOLER @ 7" O.C.	2 X 4	(6) 1/2" DIA. X 10"	-
S 2	5/8" GYPSUM WALLBOARD	BLOCKED	6d COOLER @ 7" O.C.	2 X 4	(8) 1/2" DIA. X 10"	-
S 3	3/8" PLYWOOD STRUCT - I	BLOCKED	8d @ 3"	2 X 4	(5) 5/8" DIA. X 10"	FIELD NAILING : 8d @ 12" O.C.
S 4	1/2" PLYWOOD STRUCT - I	BLOCKED	10d @ 3"	3 X 4	(8) 5/8" DIA. X 10"	FIELD NAILING : 8d @ 12" O.C.
S 5	- -	-	- -	-	-	-
S 6	- -	-	- -	-	-	-
- -	- -	-	- -	-	-	-
- -	- -	-	- -	-	-	-

Figure 12.11 Shear wall finish schedule example.

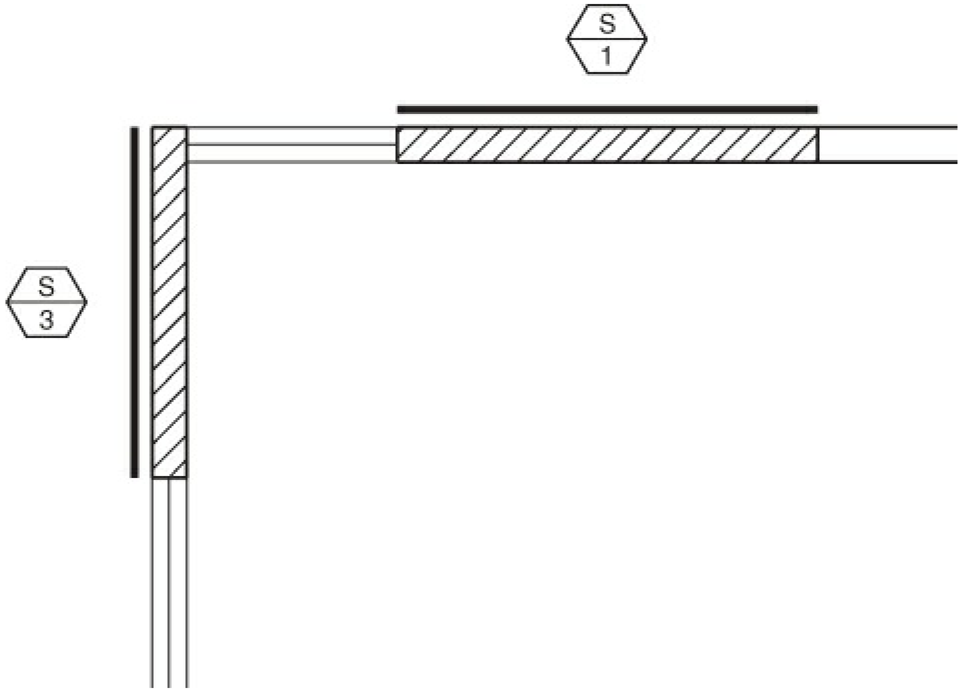


Figure 12.12 Shear wall in plan view.

Another example of a schedule that is related to a structural entity is a pier and/or spread footing schedule. This type of schedule is recommended when there are numerous spread footings of various sizes. This occurs on many commercial buildings. Figure 12.13 illustrates an example of a pier/spread footing schedule. Note the variances in the steel reinforcing requirements, the sizes of the base plates, the number and sizes of the anchor bolts, and other items. Figure 12.14 depicts how the schedule symbols may be shown on a structural foundation plan.

Pier/Spread Footing Schedule

Sym	Size	Depth	Reinforcing	Base Plate Size	Anchor Bolts & Number	Remarks
P 1	1'-6" X 1'-6"	10"	(3) 1/2" DIA. BARS ONE WAY	N.A.	N.A.	KEEP STEEL 3" CLR. OF EARTH
P 2	2'-6" X 2'-6"	12"	(4) 1/2" DIA. BARS EACH WAY	6" X 6" x 1/4"	(2) 5/8" DIA.	KEEP STEEL 3" CLR. OF EARTH
P 3	3'-6" X 3'-6"	12"	(5) 1/2" DIA. BARS EACH WAY	7" X 7" X 3/8"	(4) 5/8" DIA.	KEEP STEEL 3" CLR. OF EARTH
P 4	-	-	- -	-	-	-
- -	-	-	- -	-	-	-
- -	-	-	- -	-	-	-

Figure 12.13 Pier/spread footing schedule example.

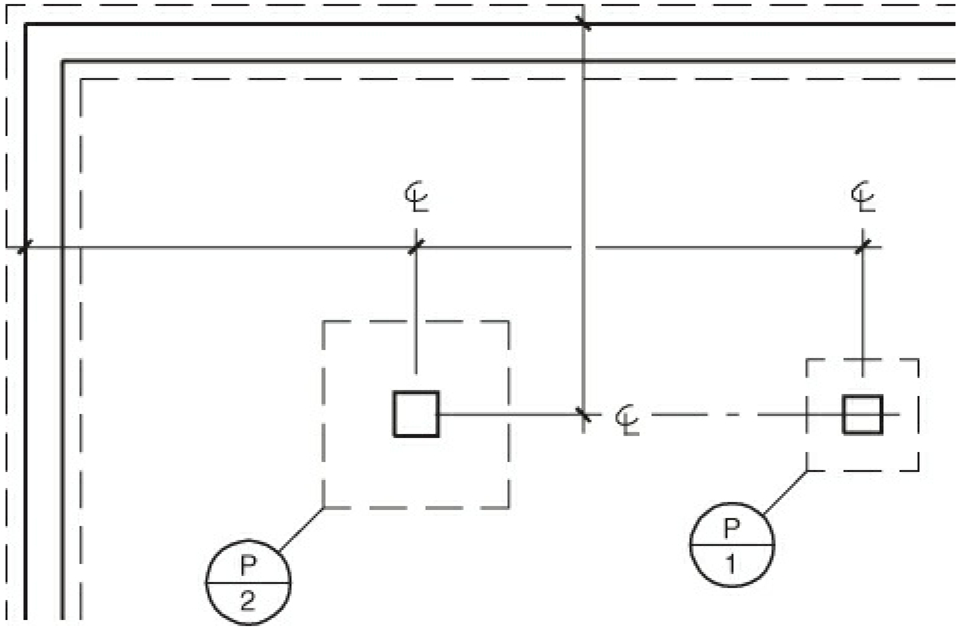


Figure 12.14 Pier/spread footing example.

A copy of a schedule can be made and attached to a set of drawings as required by the scope of work. As a project is altered, a new copy can replace the earlier one to represent the changes. In most cases, a spreadsheet or the computer program will aid in the development of a schedule (see Figure 12.15).

WINDOW SCHEDULE								
SYM.	WIDTH	HEIGHT	TYPE	FRAME	SCR.	GLAZ. AREA	VENT. AREA	REMARKS

Figure 12.15 Predrawn schedules.

CAD…GENERATED AND COMPUTER…DRAFTED SCHEDULES

To illustrate a project utilizing the abilities of a computer…aided drafting (CAD)…generated schedule system in developing layouts, three examples are given in the following figures.

Figure 12.16 shows an example of a computer…generated interior finish schedule. This schedule can be revised quickly with a computer while still preserving the basic layout for future projects.

INTERIOR FINISH SCHEDULE

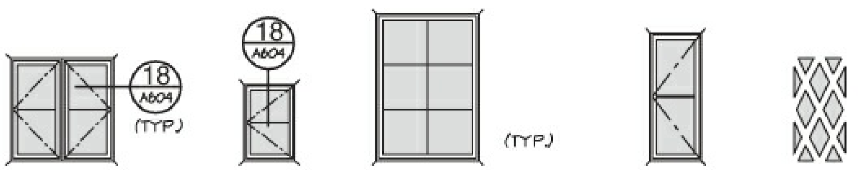
ROOM	FLOOR					BASE						WALLS						CEILINGS						CABINETS				PAINT AND STAIN																	REMARKS
																											WALLS					CEILING				TRIM				CABINET				
	CARPET	HARDWOOD	STONE	CERAMIC TILE	CONCRETE	PAINT GRADE 8" BASE	PAINT GRADE 5" BASE	STAIN GRADE 8" BASE	STONE	CERAMIC TILE	NONE	5/8" GYP. BD. W/SKIM-COAT	CERAMIC TILE WAINSCOT	WAINSCOT	STAIN-GRD. WOOD PANELING	FULL-HEIGHT CERAMIC TILE	STUCCO	5/8" TYPE 'X' GYP BD.	STAIN GRD. WOOD PANELING	STAIN GRD. T&G AND BEAMS	STAIN GRD. WOOD BEAMS/PLAST	STUCCO	RED BRICK	STAIN GRADE ALDER	PAINT GRADE	MELAMINE		PAINT	ENAMEL	FAUX FINISH	WALL PAPER		PAINT	ENAMEL	STAIN	NOT APPLICABLE	PAINT	ENAMEL	STAIN		PAINT #	ENAMEL	STAIN #		
LIVING RM.		X				X						X						X												X			X												
DINING RM.		X				X						X						X												X			X												2X6 WOOD PLANK DECKING AT FAM. RM. DECK
FAMILY RM.	X					X						X						X										X					X												
KITCHEN				X		X						X						X						X					X						X								X		
NOOK				X		X						X						X										X					X												
POWDER			X			X						X						X							X			X					X								X				
LAUNDRY				X						X		X	X					X								X			X				X												
2-CAR GARAGE					X						X	X						X										X																	
STAIRWELL		X				X						X						X										X																	
HALL	X						X					X						X										X					X												
MAST. BDRM.	X					X						X						X						X									X												
MAST. BATH			X						X			X						X						X						X				X									X		
WALK-IN CLOSET	X						X					X						X						X				X					X								X				
BED RM. #2	X						X					X						X										X					X												
BATH #2				X						X		X	X					X							X				X					X								X			
BED RM. #3	X						X					X						X										X					X												
BATH #3				X						X		X	X					X							X				X					X							X	X			
BED RM. #4	X						X					X						X										X					X												
BATH #4				X						X		X	X					X							X				X					X								X			
CELLAR					X						X	X						X										X					X												
WINE					X						X	X						X										X					X												

Figure 12.16 Interior finish schedule.

Figure 12.17 depicts a window schedule with drawings of some of the window types that will be incorporated into this project. As discussed previously in this chapter, the pictorial form adds clarity and demonstrates the symbology for window sections. Note in the glazing column that the clouded (shaded) areas refer to tempered glass. This has been done to satisfy a building department requirement and is referenced to a delta one symbol, which is required for a building department safety requirement. The architect has also added notes to indicate the alignment of the windows and doors. Notes relating to building code requirements are shown below the window types.

WINDOW SCHEDULE							
KEY	WIDTH	HEIGHT	TYPE	MATERIAL	GLAZING	HEAD HGT. FROM F.F.	REMARKS
1	2'-4"	5'-0"	D	PAINT GRD. WOOD		8'-0"	CASEMENT
2	2'-4"	5'-0"	D	•		8'-0"	CASEMENT
3	4'-8"	5'-2"	A	•		8'-0"	FRENCH CASEMENT
4	4'-8"	4'-0"	A	STAIN GRD. WOOD	TEMPERED	6'-8"	FRENCH CASEMENT
5	4'-8"	5'-0"	A	PAINT GRD. WOOD		8'-0"	FRENCH CASEMENT
6	2'-0"	4'-0"	D	•	TEMPERED	6'-8"	CASEMENT
7	2'-0"	4'-0"	D	•		6'-8"	CASEMENT
8	2'-0"	4'-0"	D			6'-8"	CASEMENT
9	2'-0"	3'-0"	B	•		8'-0"	CASEMENT
10	6'-0"	4'-0"	C	•		6'-8"	FIXED
11	2'-0"	4'-0"	D	•		6'-8"	CASEMENT
12	4'-0"	4'-0"	A	•		6'-8"	FRENCH CASEMENT, EGRESS (12.25 SQ. FT.)
13	4'-0"	3'-6"	A	•		6'-8"	FRENCH CASEMENT
14	2'-0"	3'-0"	B	•	TEMPERED	6'-8"	CASEMENT
15	2'-0"	4'-0"	E	•		6'-8"	FIXED, SEE ELEV
16	4'-0"	4'-0"	A	•	TEMPERED	6'-8"	FRENCH CASEMENT
17	2'-0"	4'-0"	D	•		6'-8"	CASEMENT
18	2'-0"	4'-0"	E	•	TEMPERED	6'-8"	INSWING CASEMENT, SEE ELEV
19	2'-0"	4'-0"	D	•	TEMPERED	6'-8"	CASEMENT
20	2'-0"	4'-0"	E	•		6'-8"	INSWING CASEMENT, SEE ELEV
21	2'-0"	3'-0"	B	•		6'-8"	CASEMENT

WINDOW TYPES



TYPE "A" TYPE "B" TYPE "C" TYPE "D" TYPE "E"

NOTES:

1. ALIGN TOP OF WINDOWS WITH TOP OF DOORS SO THAT TOP EDGES OF DOORS AND WINDOWS ALIGN IN A LEVEL PLANE ABOVE FINISH FLOOR.

2. ALL ESCAPE OR RESCUE WINDOWS SHALL HAVE A MINIMUM NET CLEAR OPENABLE AREA OF 5.7 SQ. FT.. THE MINIMUM NET CLEAR OPENABLE HEIGHT DIMENSION SHALL BE 24". THE MINIMUM NET CLEAR OPENABLE WIDTH DIMENSION SHALL BE 20" WHEN WINDOWS ARE PROVIDED AS A MEANS OF ESCAPE OR RESCUE. THEY SHALL HAVE A FINISHED SILL HEIGHT NOT MORE THAN 44" ABOVE FIN. FLR..

3. SKYLIGHTS SHALL HAVE A NON-COMBUSTIBLE FRAME GLAZED WITH DUAL GLAZING OF HEAT STRENGTHENED OR FULLY TEMPERED GLASS OR SHALL BE A 3/4-HOUR FIRE-RESISTIVE ASSEMBLY

4. WINDOWS WITH SILLS LESS THAN 5'-0" ABOVE TUB OR SHOWER FLOOR SHALL BE TEMPERED

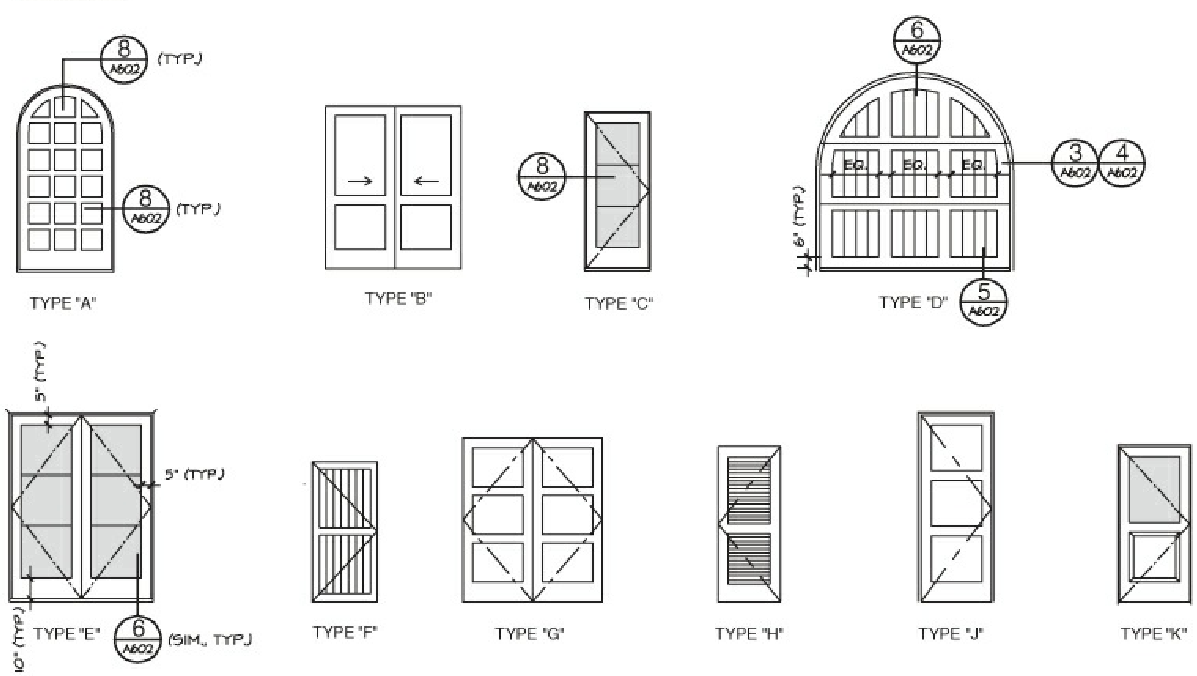
Figure 12.17 Window schedule and types of windows.

The types of doors specified for this project are shown in pictorial form (see Figure 12.18). Types of doors have been depicted pictorially for clarity and referencing. A clouded area for a specific door illustrates a revision and requirement by the governing building department. These types of doors are keyed with a letter on the door schedule. The computer offers the flexibility to alter or revise the schedule layouts types and sizes for projects that may have different requirements.

DOOR SCHEDULE

KEY	WIDTH	HEIGHT	THICK.	TYPE	MATERIAL	GLAZING	REMARKS
1	2'-8"	6'-8"	2 1/4"	C	PAINT GRD. WOOD	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
2	(2)-3'-0"	8'-0"	2 1/4"	E	"	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
3	4'-0"	8'-0"	2 1/4"	A	STAIN GRD. WOOD		
4	8'-6'	8'-3"		D			GARAGE OVERHEAD SECTIONAL DOOR (SEE ELEVATIONS)
5	8'-6"	8'-3"		D	"		GARAGE OVERHEAD SECTIONAL DOOR (SEE ELEVATIONS)
6	3'-0"	6'-8"	2 1/4"	K	PAINT GRD. WOOD		
7	(2)-2'-0"	5'-0"		F	"		TRASH AREA, GATE
8	(2)-3'-0"	8'-0"	2 1/4"	E	"	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
9	(2)-3'-0"	8'-0"	2 1/4"	E	"	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
10	(2)-3'-0"	8'-0"	2 1/4"	E	"	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
11	(2)-2'-6"	6'-8"	2 1/4"	E	"	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
12	2'-6"	6'-8"	1 3/4"	J	"		
13	(2)-2'-0"	6'-8"	1 3/4"	G	"		
14	3'-0"	6'-8"	1 3/4"	J	"		20 MIN. RATED, SELF-CLOSING & TIGHT FITTING
15	2'-8"	6'-8"	1 3/4"	J	"		
16	2'-6"	6'-8"	1 3/4"	J	"		
17	(2)-2'-0"	6'-8"	1 3/4"	G	"		
18	(2)-2'-0"	6'-8"	1 3/4"	G	"		
19	2'-6"	6'-8"	1 3/4"	J	"		
20	(2)-2'-6"	6'-8"	1 3/4"	G	"		
21	(2)-3'-0"	8'-0"	1 3/4"	E	"	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
22	(2)-3'-0"	8'-0"	1 3/4"	E	"	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
23	(2)-2'-6"	6'-8"	1 3/4"	E	"	TEMP.	FRENCH DOORS (SEE ELEVATIONS)
24	(2)-2'-0"	6'-8"	1 3/4"	G	"		
25	(2)-2'-0"	6'-8"	1 3/4"	G	"		
26	2'-6"	6'-8"	1 3/4"	J	"		
27	2'-8"	6'-8"	1 3/4"	J	"		
28	2'-8"	8'-0"	1 3/4"	J	"		
29	2'-6"	8'-0"	1 3/4"	J	"		
30	(2)-1'-6"	8'-0"	1 3/4"	G	PAINT GRD. WOOD		
31	2'-6"	8'-0"	1 3/4"	J	PAINT GRD. WOOD		
32	(2)-1'-0"	8'-0"	1 3/4"	G	"		
33	2'-6"	8'-0"	1 3/4"	J	"		
34	2'-8"	6'-8"	1 3/4"	H	"		
35	2'-8"	6'-8"	1 3/4"	J	"		
36	(2)-4'-0"	6'-8"	1 3/4"	B	"		
37	2'-6"	6'-8"	1 3/4"	J	"		

DOOR TYPES



NOTES:

1. ALL DOORS TO BE SOLID CORE.
2. BOTTOM OF INTERIOR DOORS TO BE 3/8" ABOVE FIN. FLR.

Figure 12.18 Door schedule and types of doors.

If a set of construction documents was produced on the computer, chances are that a basic office standard template (pattern) was produced. Every CAD drafter should be able to produce a new basic template as office standards change. The new pattern will change as the technology changes for architectural installation of windows, doors, and so forth.

Schedule templates can be produced on the computer by simply drawing lines and arranging them horizontally and vertically. The text for the main title and the column titles is entered by typing a placeholder in each position. If the first phrase is positioned and centered carefully, the remaining columns will also be centered. Next, edit the placeholder to reflect the desired column titles and change the size if necessary. The text will automatically center the new titles. An alternative option is to link an excel file to a CAD program. Look at Figure 12.19. Because we are producing a generic schedule, put a hyphen (dash) in the unused spaces as a placeholder. The user of this schedule need only replace the hyphens with the desired information: height, width, material, and so on. All of the information will be automatically centered or placed with the margin to the left, as shown in the "Material" column in Figure 12.20.

Window Schedule

Key	Width	Height	Type	Material	Glazing	
-	-	-	-	-	-	
-	-	-	-	-	-	
-	-	-	-	-	-	
-	-	-	-	-	-	
-	-	-	-	-	-	
-	-	-	-	-	-	
-	-	-	-	-	-	
-	-	-	-	-	-	
-	-	-	-	-	-	
-	-	-	-	-	-	

Figure 12.19 Partial template of a schedule with placeholder.

Window Schedule

Key	Width	Height	Type	Material	Glazing
1	2'-4"	5'-0"	D	PAINT GRADE WOOD	-
2	2'-4"	5'-0"	D	-	-
3	4'-8"	5'-2"	A	-	-
4	4'-8"	4'-0"	A	STAIN GRADE WOOD	TEMPERED
5	4'-8"	5'-0"	A	PAINT GRADE WOOD	-
6	2'-0"	4'-0"	D	-	TEMPERED
7	2'-0"	4'-0"	D	-	-
8	2'-0"	4'-0"	D	-	-
9	2'-0"	3'-0"	B	-	-
10	6'-0"	4'-0"	C	-	-

Figure 12.20 Replacing the placeholder with live information.

Figure 12.21 is a depiction of a completed series of schedules as presented to the building department for review. Depending on the size of the project, all schedules can be placed on the same sheet for organization's sake.

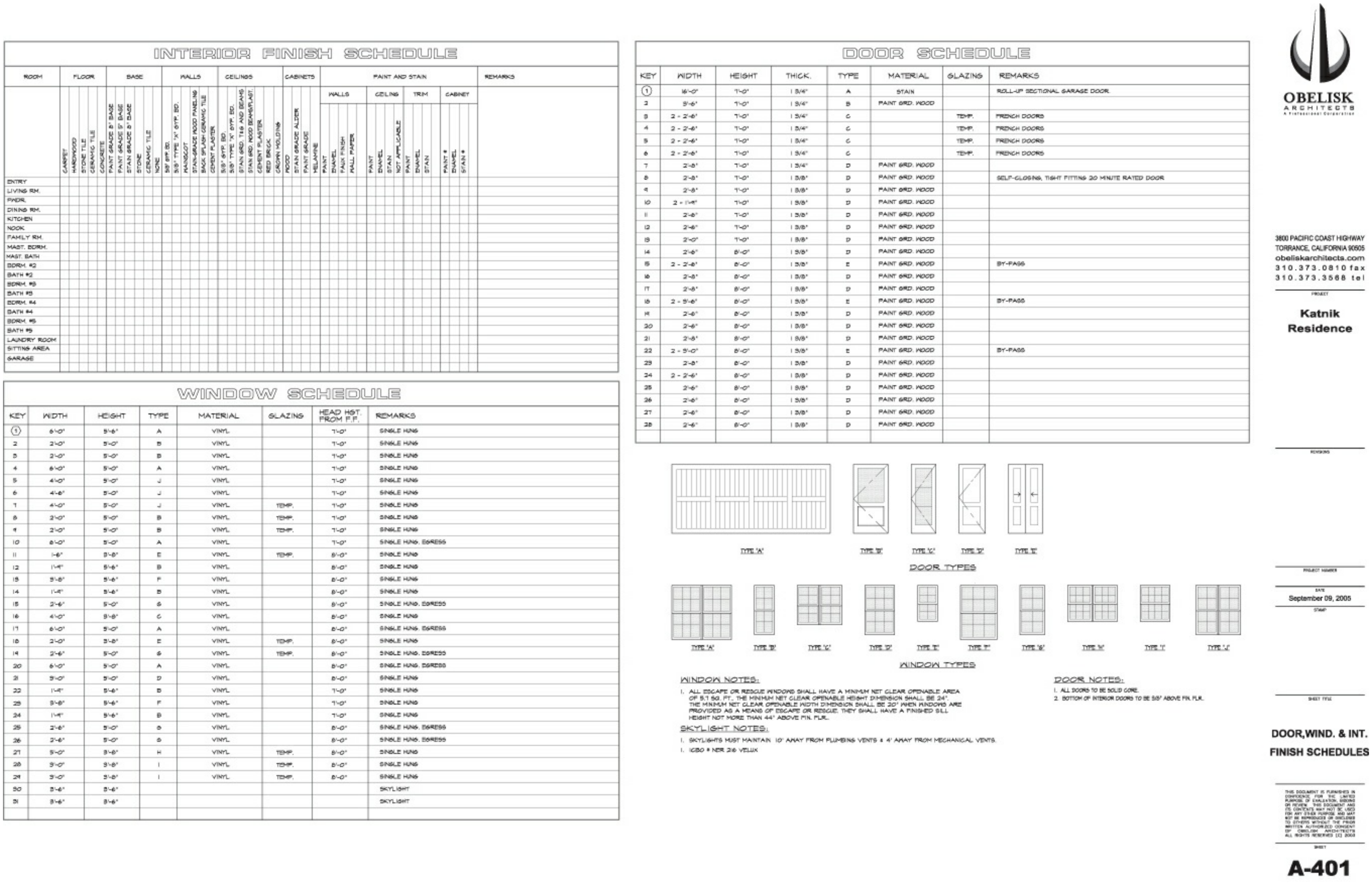


Figure 12.21 Completed door, window, and finish schedules on a plot sheet.

SCHEDULES USING BIM

If a set of construction documents was produced using BIM, odds are the schedules can be generated automatically. The schedules are tied to the parametric design of the software, which will generate the table for you. This is the ideal situation, as the software's capabilities improve the accuracy of the schedules for both the size and quantity of windows, doors, and finishes. Previously, it was common for a drafter to spend hours reviewing a series of schedules; here the software does much of the thinking for you. There are opportunities to customize the schedules and the data on the schedule, but it is truly amazing how far we have come from the traditional methods of scheduling. See Figures 12.22 and 12.23.

Window Schedule								
Mark	Type	Width	Height	Head Height	Sill Height	Family	Family and Type	Description
1	36" x 48"	3' - 0"	4' - 0"	6' - 0"	2' - 0"	Casement 3x3	Casement 3x3 with Trim: 36"	
2	16" x 72"	1' - 4"	6' - 0"	9' - 0"	3' - 0"	Fixed	Fixed: 16" x 72"	
3	36" x 60"	3' - 0"	5' - 0"	8' - 0"	3' - 0"	Casement 3x3	Casement 3x3 with Trim: 36"	
4	24" x 24"	2' - 0"	2' - 0"	5' - 0"	3' - 0"	Fixed	Fixed: 24" x 24"	
5	36" x 24"	3' - 0"	2' - 0"	5' - 0"	3' - 0"	Fixed	Fixed: 36" x 24"	
6	24" x 48"	2' - 0"	4' - 0"	11' - 0"	7' - 0"	Fixed	Fixed: 24" x 48"	
7	36" x 48"	3' - 0"	4' - 0"	7' - 0"	3' - 0"	Casement 3x3	Casement 3x3 with Trim: 36"	

Figure 12.22 Completed window schedule utilizing BIM.

Door Schedule					
Mark	Width	Height	Head Height	Family and Type	Description
1	6' - 0"	7' - 0"	7' - 0"	Sliding-2 panel: 72" x 84" Metal	
2	6' - 0"	7' - 0"	7' - 0"	Sliding-2 panel: 72" x 84" Metal	
3	6' - 0"	7' - 0"	7' - 0"	Sliding-2 panel: 72" x 84" Metal	
4	6' - 0"	7' - 0"	7' - 0"	Sliding-2 panel: 72" x 84" Metal	
5	6' - 0"	7' - 0"	7' - 0"	Sliding-2 panel: 72" x 84" Metal	
6	6' - 0"	7' - 0"	7' - 0"	Sliding-2 panel: 72" x 84" Metal	
7	2' - 6"	7' - 0"	7' - 0"	Single-Flush: 30" x 84"	
8	2' - 6"	7' - 0"	7' - 0"	Single-Flush: 30" x 84"	
9	2' - 6"	7' - 0"	7' - 0"	Single-Flush: 30" x 84"	
10	2' - 6"	7' - 0"	7' - 0"	Single-Flush: 30" x 84"	

Figure 12.23 Completed door schedule utilizing BIM.

BIM Schedule

In traditional drafting, we constructed schedules much like a spreadsheet is built: cell by cell. With BIM those days are gone. The program is designed to create schedules of many components of a building, not just windows, doors, fixtures, and finishes. For example, when you place a new window, the program automatically numerates it in the floor plan and cross…references it to the window schedule. Most of the data you need for the schedule is already built into the software. The schedule will report with absolute accuracy the data you input. That is great news—provided the information is correct. However, if it is determined that a change is desired (say, a window would be better in a larger size), you can simply enlarge it and the program will automatically update the schedule.

You will have to spend some downtime with BIM customizing the schedules to look the way you want them to look.

A view tab is utilized to bring up specific schedules. The lengthy list of options is almost limitless, ranging from building areas to electric equipment, to fascias or even eave gutters. All of these tabs are broken down even further to allow you to select or mark the fields you require for your customized schedule. Additional data can be customized by building level. Though this function may not be required for door or windows, it is ideal for floor area calculations.

Once the schedule is formatted as desired, it is simply a matter of dragging and dropping it onto the desired sheet and location to plot it.

Key Terms

head

hollow core (HC)

jamb

pictorial schedule

sill

solid core (SC)

Chapter 13
ARCHITECTURAL DETAILS AND VERTICAL LINKS (STAIRS/ELEVATORS)

ARCHITECTURAL DETAILS

Definition

Architectural **details** are enlarged drawings of specific architectural assemblies. These details are usually provided by the architect, and structural details are furnished by the structural engineer.

Architectural details are done for many different construction assemblies, including door and window details, fireplace details, stair details, and wall and roof assemblies. The number and kind of details needed for a given project depend entirely on the architect's estimate of what is needed to clarify the construction process. The contractor may request

additional architectural details in the construction stage.

FREEHAND DETAIL SKETCHES

Architectural detailers often start with **freehand sketches** and an architectural scale in order to solve different construction assemblies in a structure. Once the details have been formulated in a scaled freehand sketch, they are then ready to be drafted in final form. Many details, such as standard foundation and wall assemblies, are relatively straightforward and do not require freehand sketches. The following sections provide examples of residences to give you an understanding of what is required.

The drawing of details from scratch requires a drafter who understands detailing relative to the detail area available. One should not draft a detail and plot it to fit the space, but rather should begin with the office format sheet and then decide whether **keynotes** (notes written in chart form off to one side of the detail) will be used and what type of noting will be used. The steps required to create a detail and to determine what formatting to use are covered later in this chapter.

Details in Construction Documents

Freehand Detail Sketches. Architectural details encompass many construction assemblies, such as residences with unique foundation details. Such residences may have unusual geometric shape, similar to that of a pentagon. Figure 13.1 shows a freehand sketch detail of an exterior bearing footing for such residence. There are some nonstandard conditions in this detail, such as steel anchor clips for connection of the floor joists to the mudsill (for lateral support), steel reinforcing placement in the wall for earth retention, and location of (and installation requirements for) a footing drain. Figures 13.2 and 13.3 show two other exterior footing conditions. Figure 13.2 shows a concrete floor condition below grade, and Figure 13.3 shows the wood deck connection to the exterior footing. Finally, Figure 13.4 shows an interior concrete…block wall and its foundation.

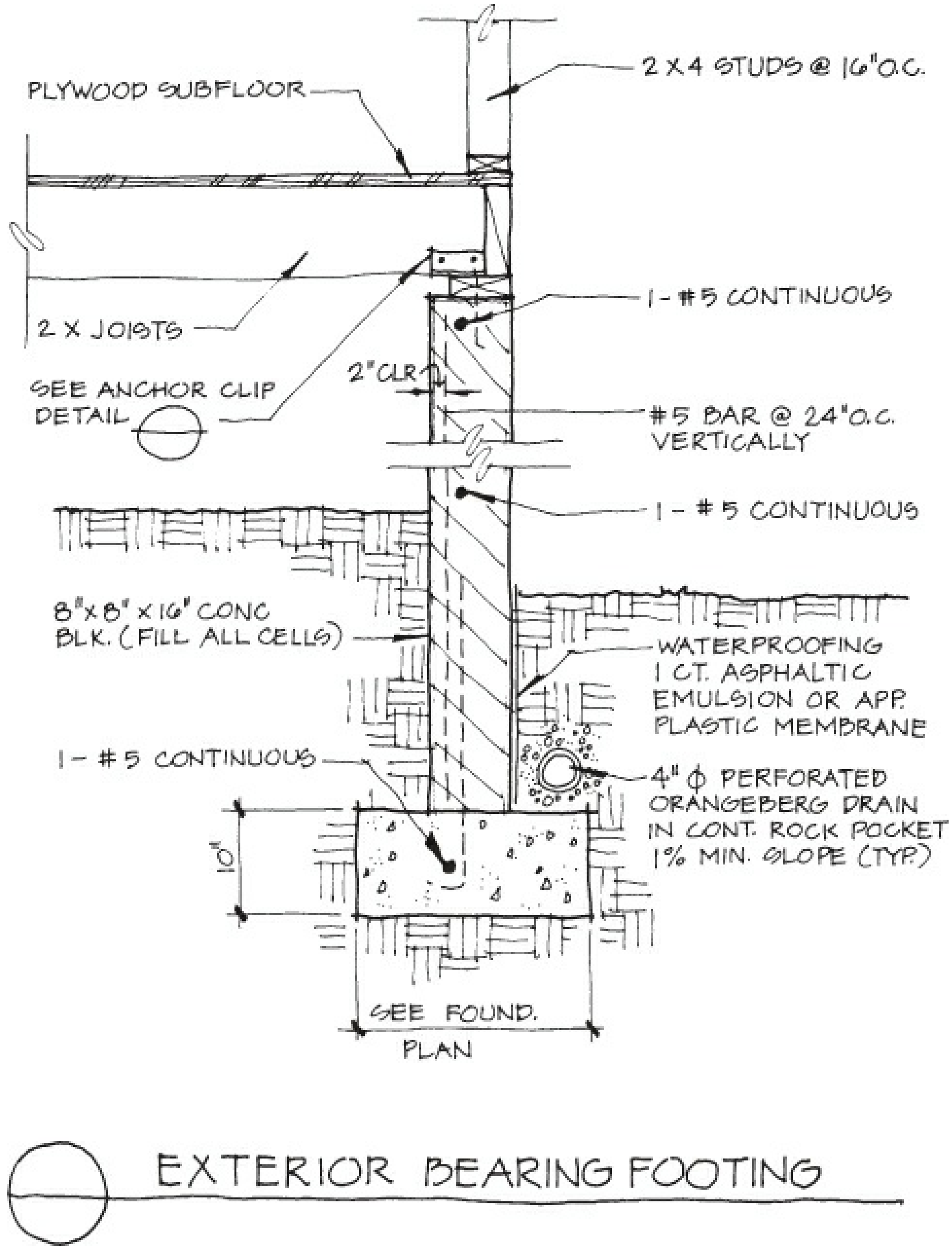


Figure 13.1 Detail of exterior bearing footing.

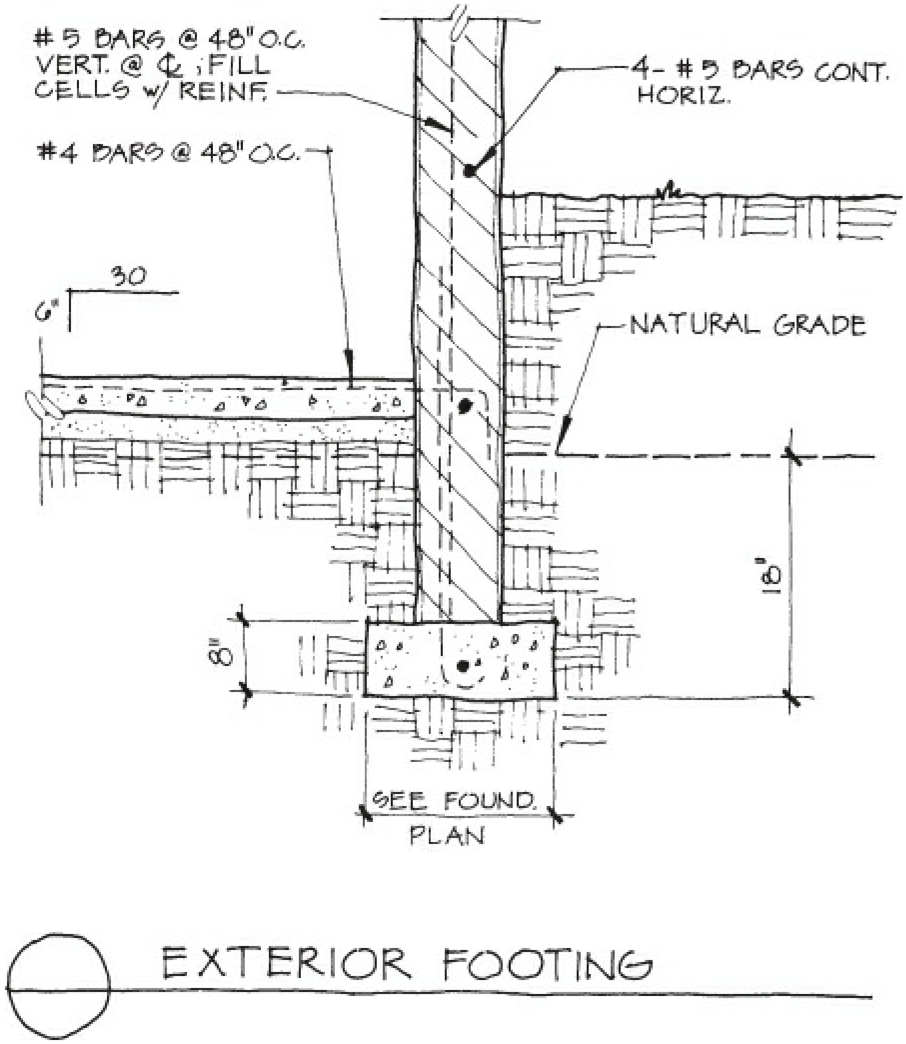


Figure 13.2 Detail of exterior footing.

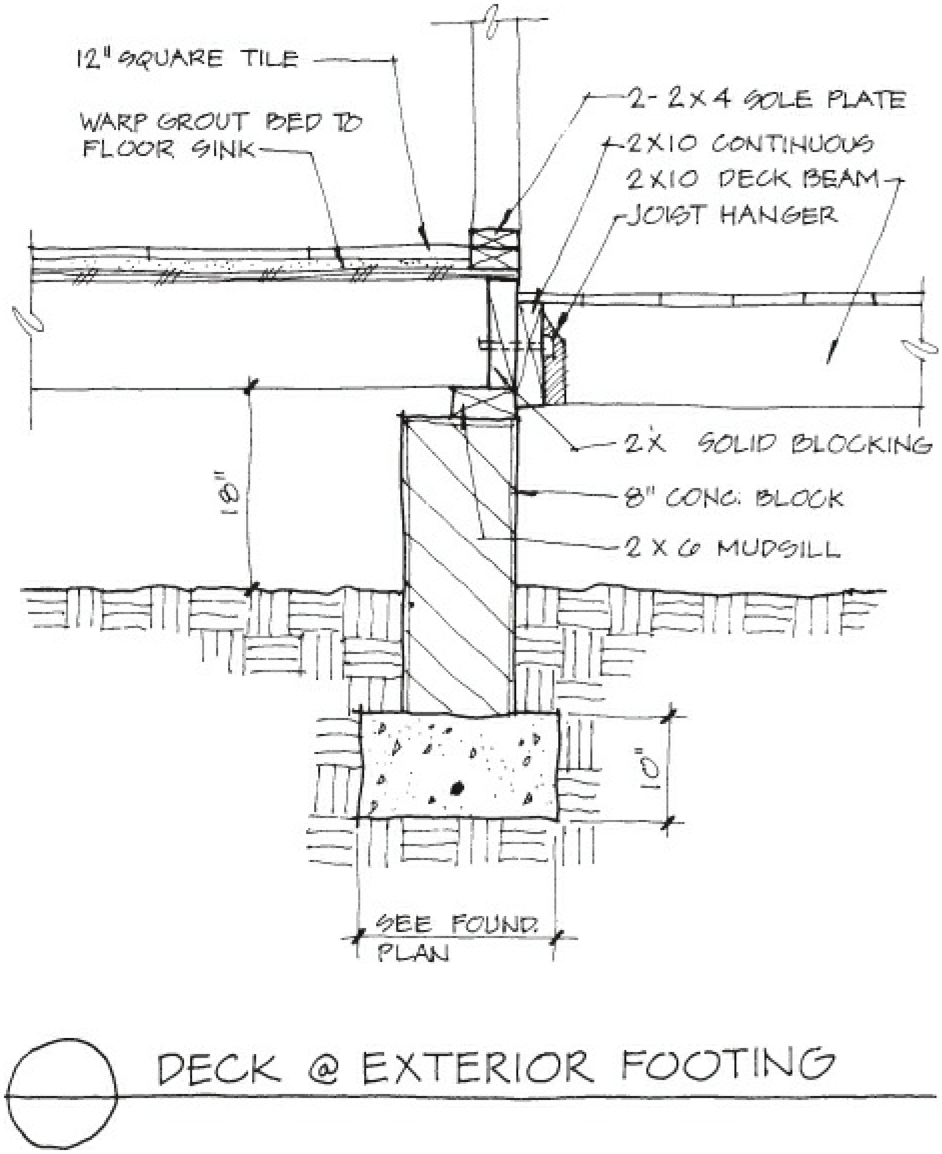


Figure 13.3 Detail of deck at exterior footing.

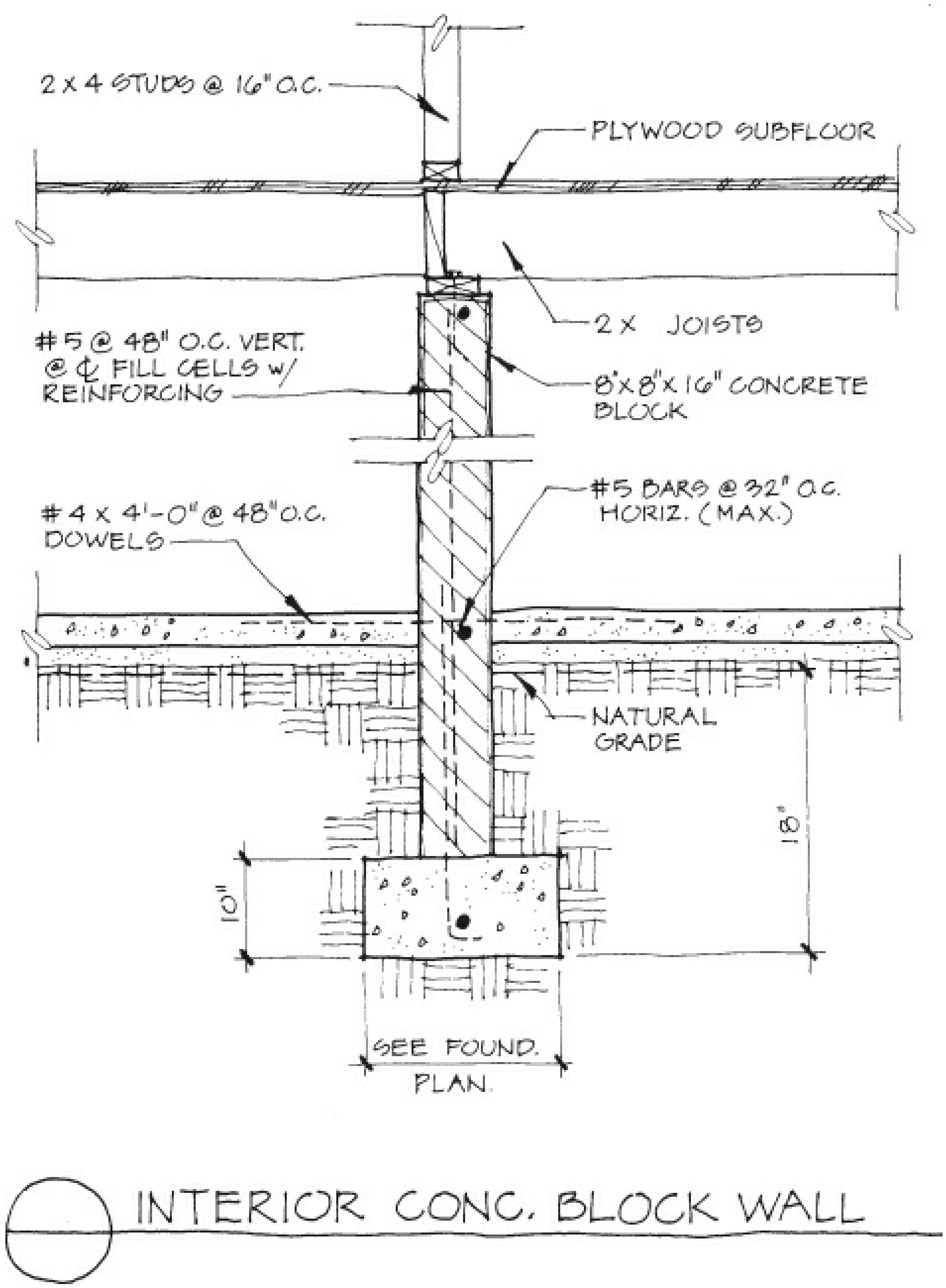


Figure 13.4 Detail of interior concrete…block wall.

Figure 13.5 shows a square concrete pier and reinforcing bars required to support a heavy concentrated load distributed by a 6″ × 6″ post. Study each of these carefully before proceeding further.

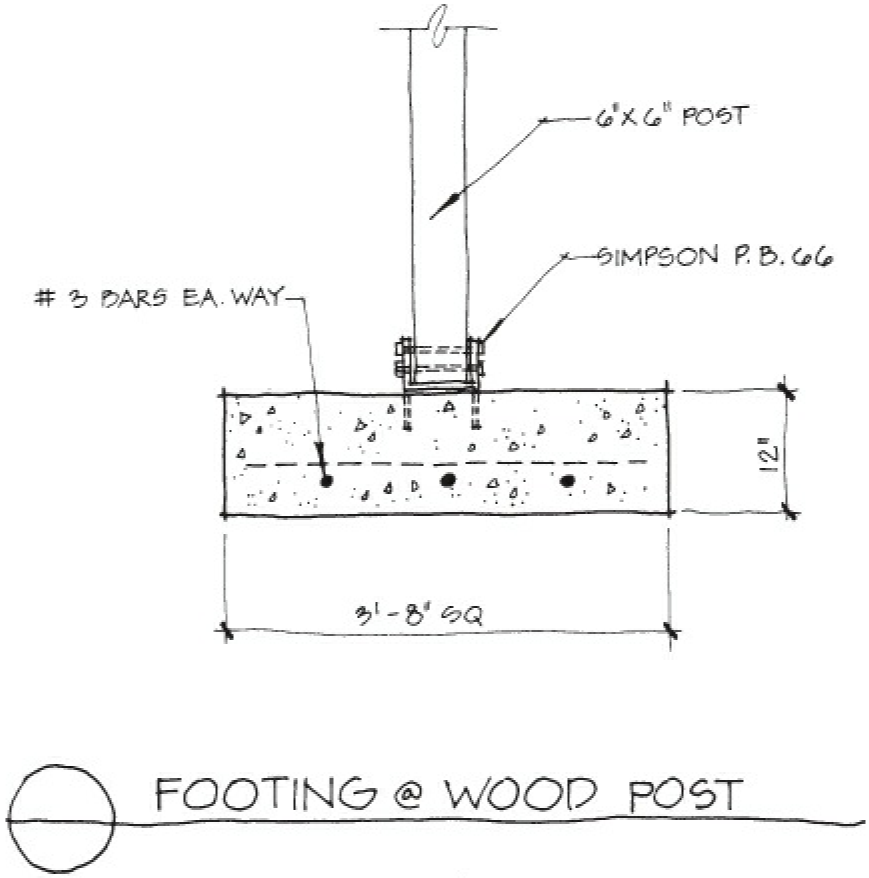


Figure 13.5 Detail of footing at wood post.

If you are asked to detail a wood beam and masonry wall connection, with the required assembly information, first draw a freehand sketch that includes the necessary information. Figure 13.6 shows such a sketch. The size of the steel plate dictates the masonry wall offset, and the embedment of the anchor bolts is 10″.

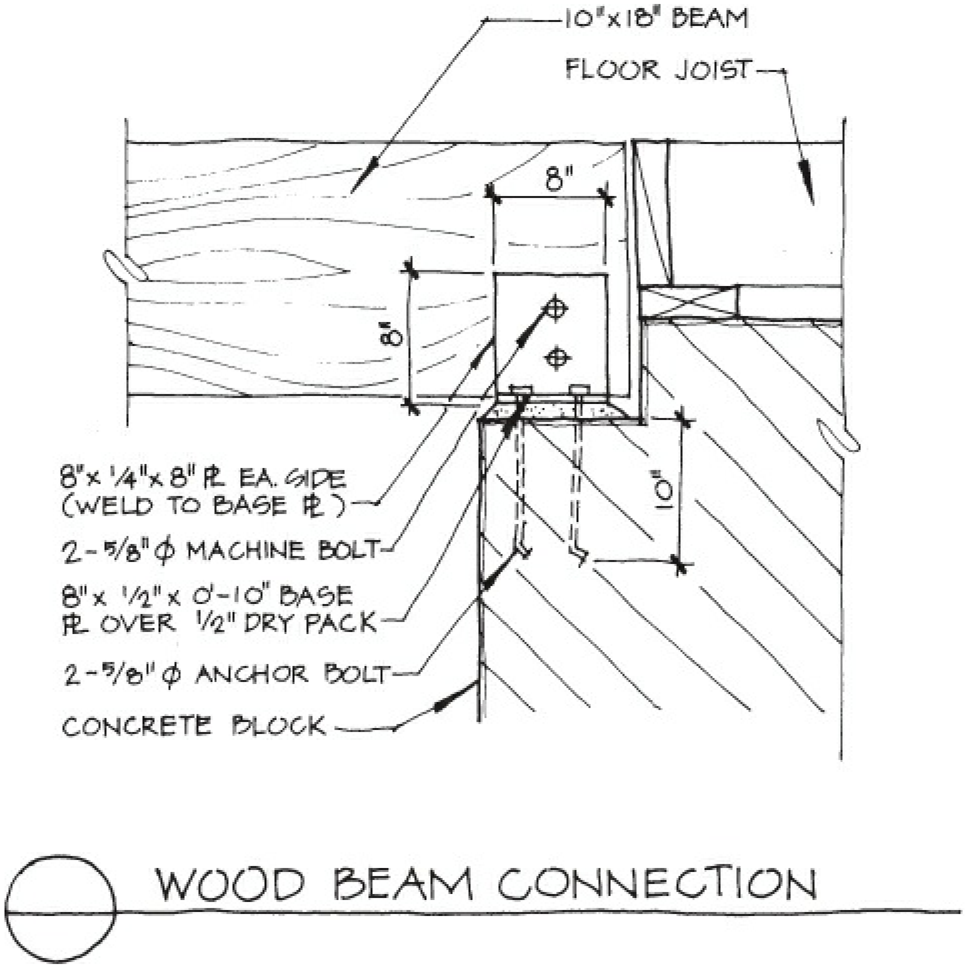


Figure 13.6 Detail of wood beam connection.

An important factor in architectural detailing is providing details that are an integral part of the architectural design of the building. For example, if floor cantilevers and wood soffits are an integral part of the design (see Figure 13.7), first design and solve these assemblies in sketch form before completing the final detail. Creativity and craftsmanship in architectural detailing are as important as any other factors in designing a structure.

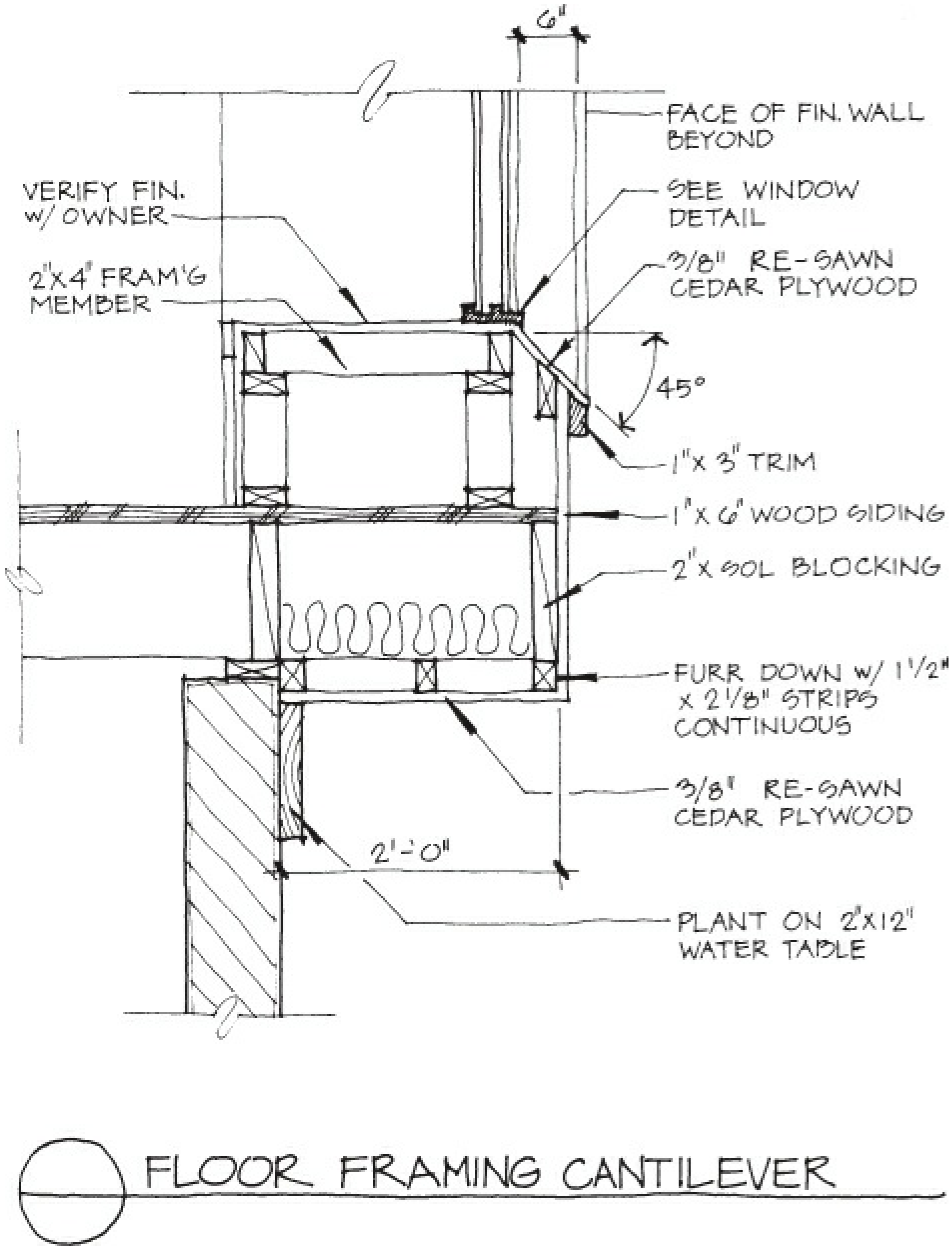
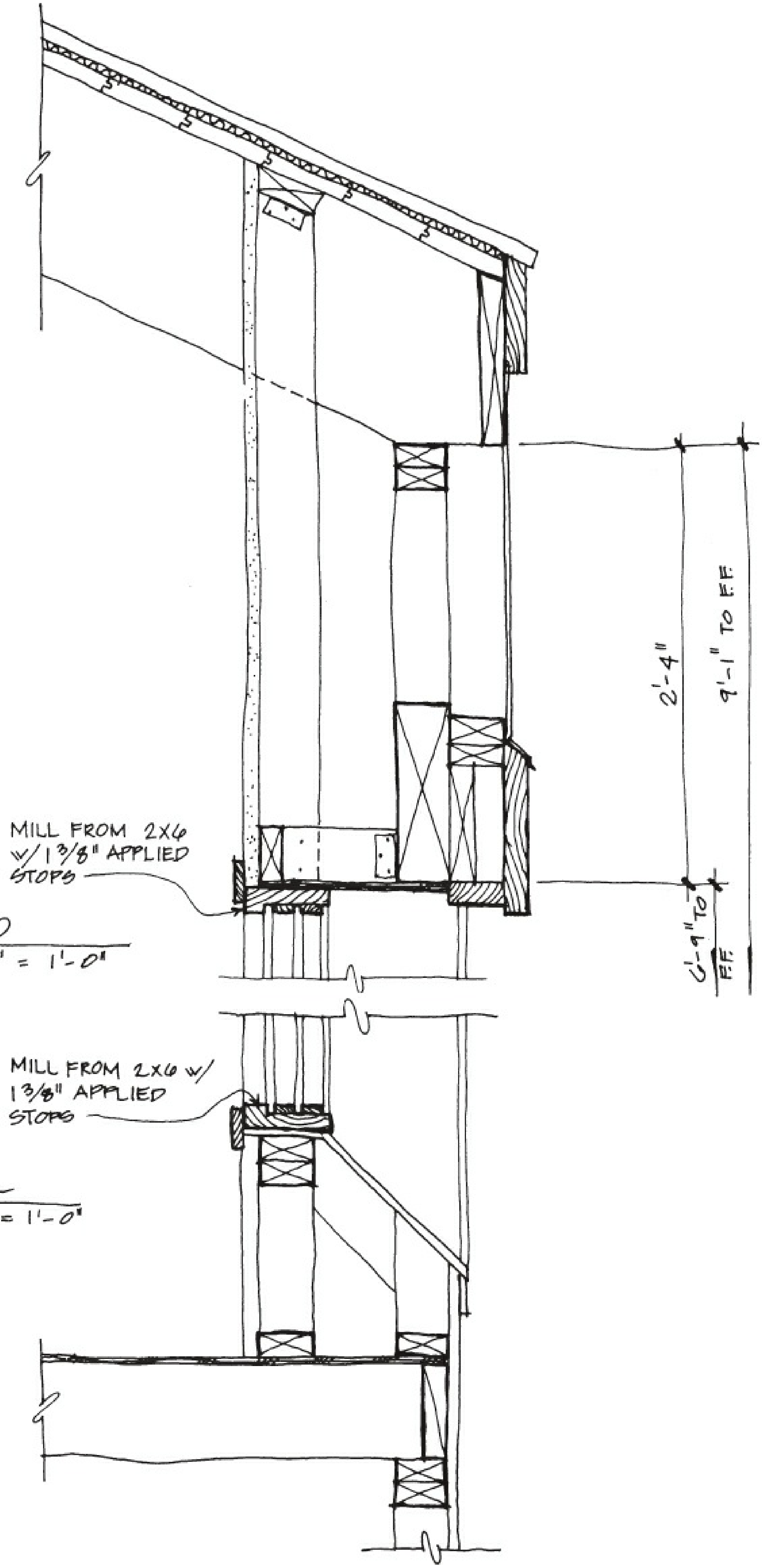


Figure 13.7 Detail of floor framing cantilever.

In this particular detail, we thought that the top of the head section of the windows and doors should have a direct relationship to the eave assembly. Therefore, we detailed the eave assembly with the various wood members forming a wood soffit directly above the head section of the window. See Figure 13.8. We sketched in detail the windowsill and exterior wall assembly projecting down from the head section. Using both Figures 13.7 and 13.8, it was possible to design and detail the **jamb** section for this particular opening, using the established head and sill section as a guide for the detailed assembly.



W
1
FIXED HEAD
SCALE: 1 1/2" = 1'-0"

W
2
FIXED SILL
SCALE: 1 1/2" = 1'-0"

Figure 13.8 Detail of eave and window head sill.

Details

Foundation Details

The architectural details are for a beach residence project that is fairly conventional but still worth investigating with freehand drawings. For example, we sketched a foundation detail for a two…story residence to take into account the sandy soil conditions. Figure 13.9 shows a detail for the exterior bearing wall. Because this soil did not provide good bearing qualities, we used horizontal reinforcing rods at the top and bottom of the foundation wall. Non…bearing walls still required a minimal footing to support the weight of the wall and a depth of concrete to receive the anchor bolts. Because this residence has a change of floor levels, we provided a detail through the floor transitions. Figure 13.10 shows a detail at a location that has incorporated the **risers** and **tread**. (A *riser* is the vertical dimension of a stair step and the *tread* is the horizontal dimension.) The risers and tread are dimensioned, as are rebar ties for the connection of the upper concrete floor. (Rebar ties act as dowels to join two concrete elements.)

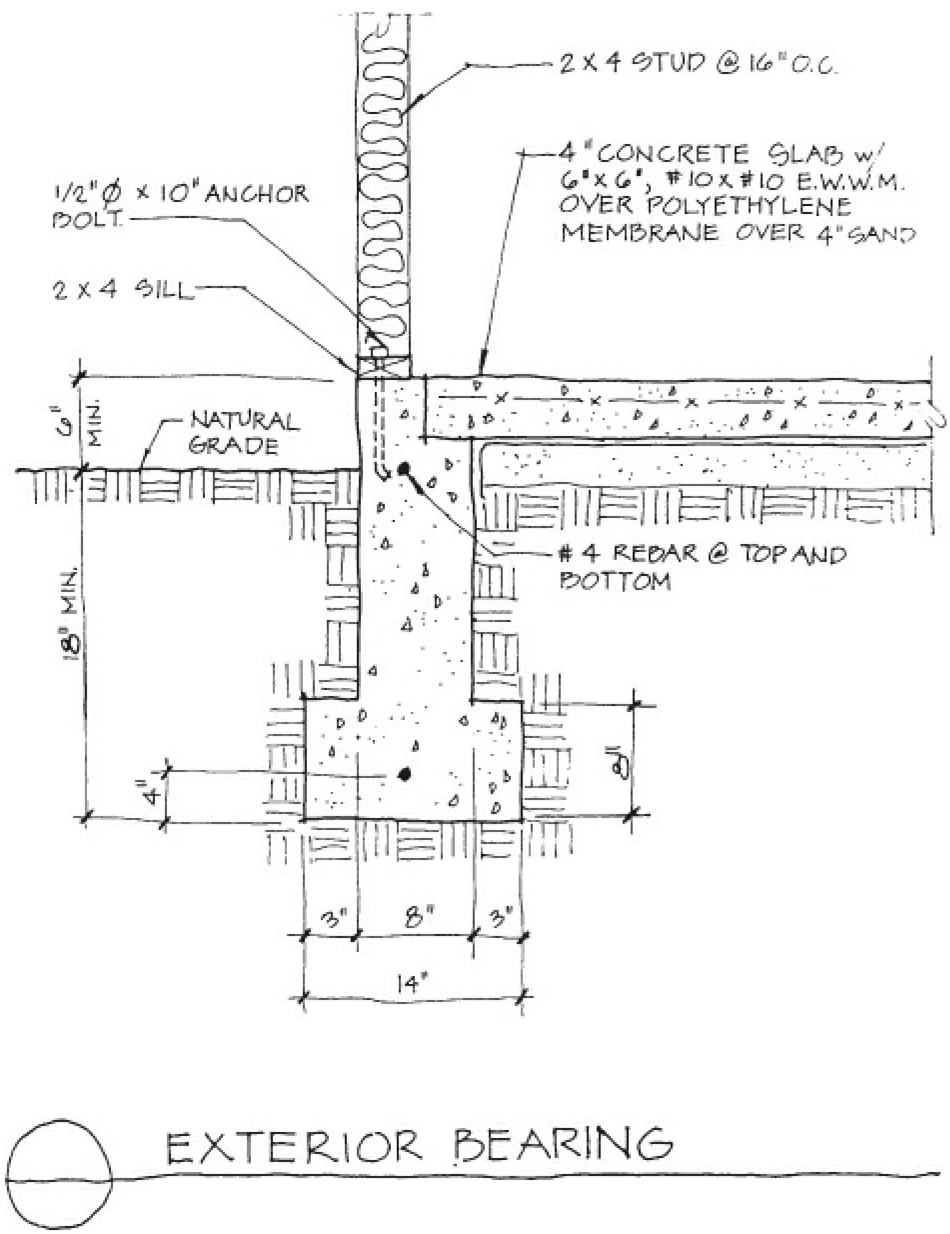


Figure 13.9 Detail of exterior bearing footing.

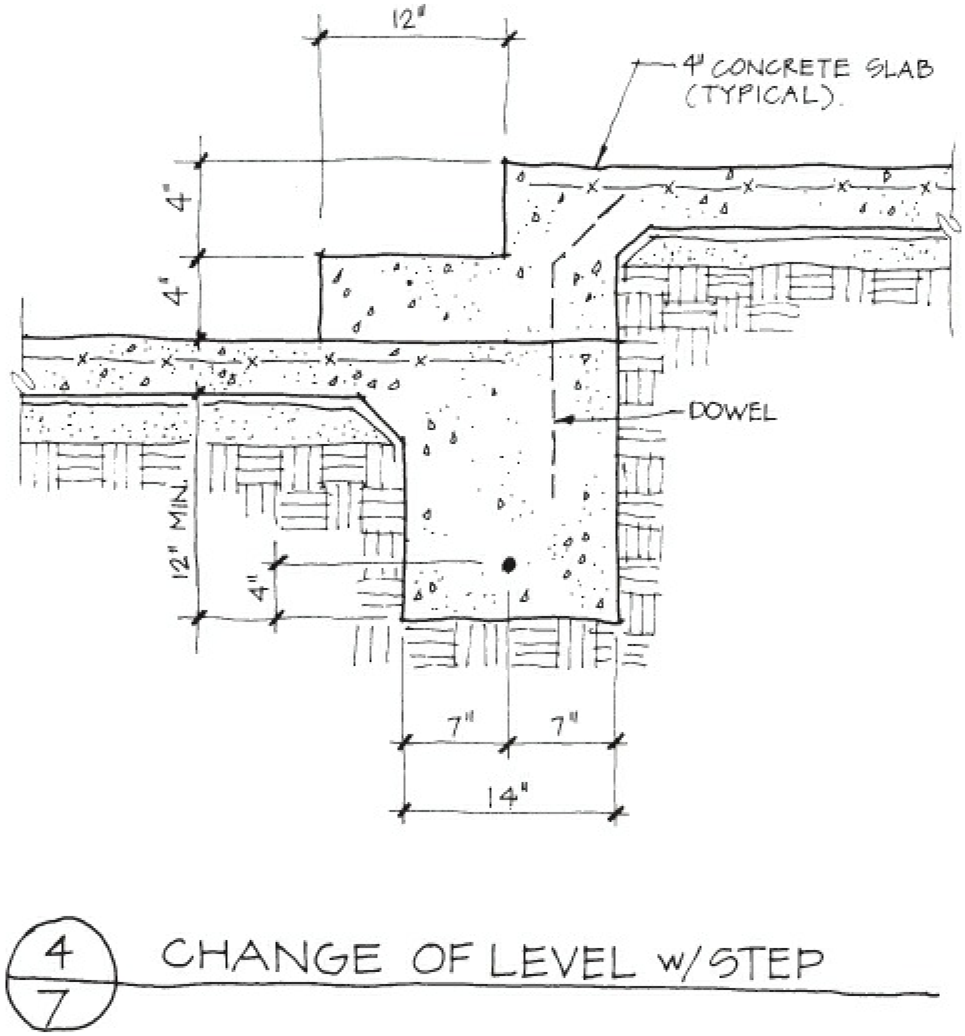


Figure 13.10 Detail of change of level with step.

A large storage area and a mechanical room were located in the basement. A detail was needed to show the assembly for the basement and floor‐level changes. See Figure 13.11. The wood stud wall has been offset in front of the upper‐level concrete floor to provide a nailing surface for the wall finishes at both levels.

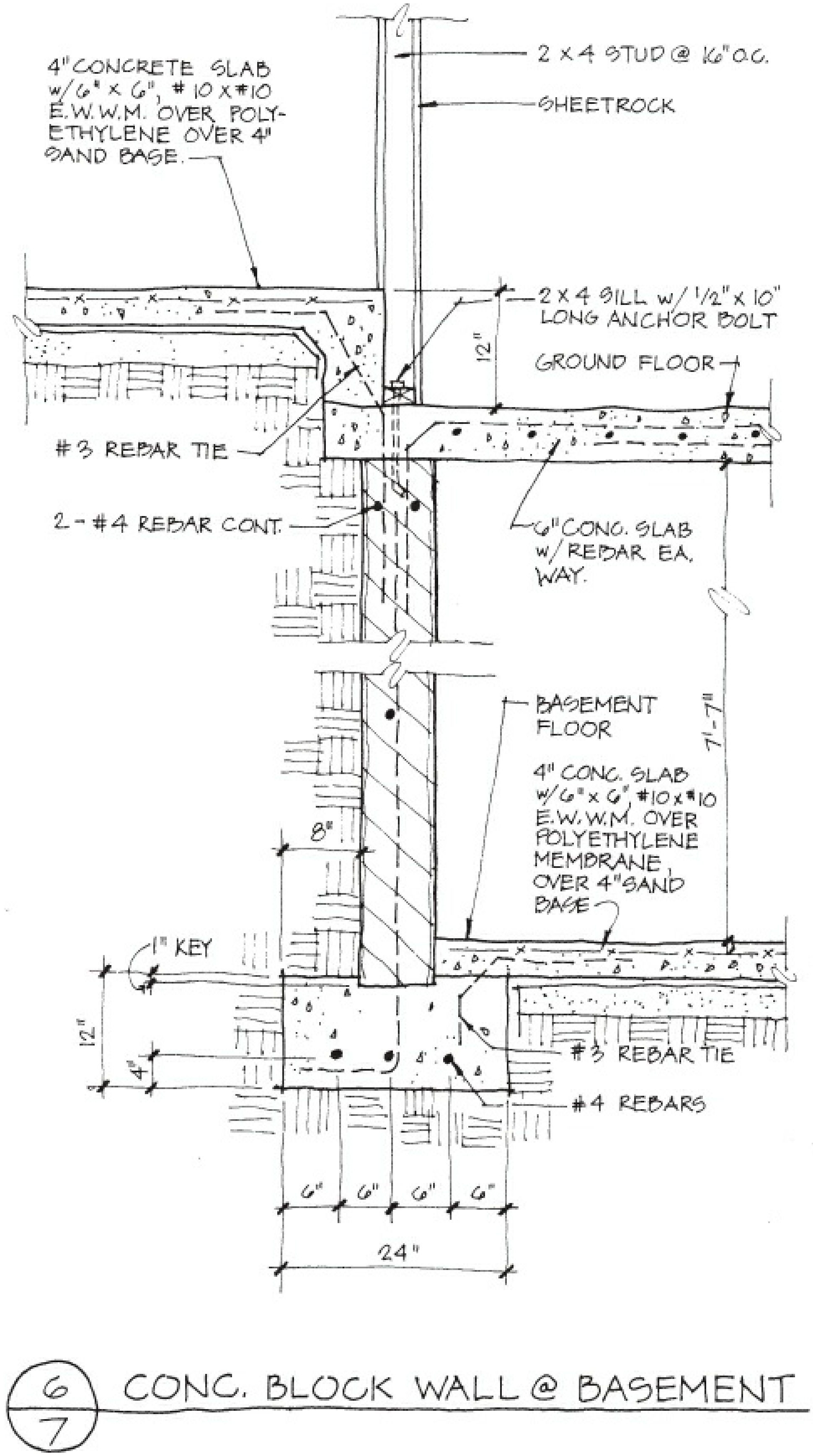


Figure 13.11 Detail of concrete…block wall at basement—slab.

Details for Framing Assemblies

Architectural details for framing assemblies were also provided in these construction documents. One example is the eave detail. First, the project designer did a freehand drawing. The freehand drawing was then given to a drafter for final drawing. Figure 13.12

shows the freehand sketch. Figure 13.13 shows a study of a deck and handrail detail located directly above a recessed garage door. The deck assembly at the building wall is also detailed because proper flashing and drainage are needed to prevent water leaks.

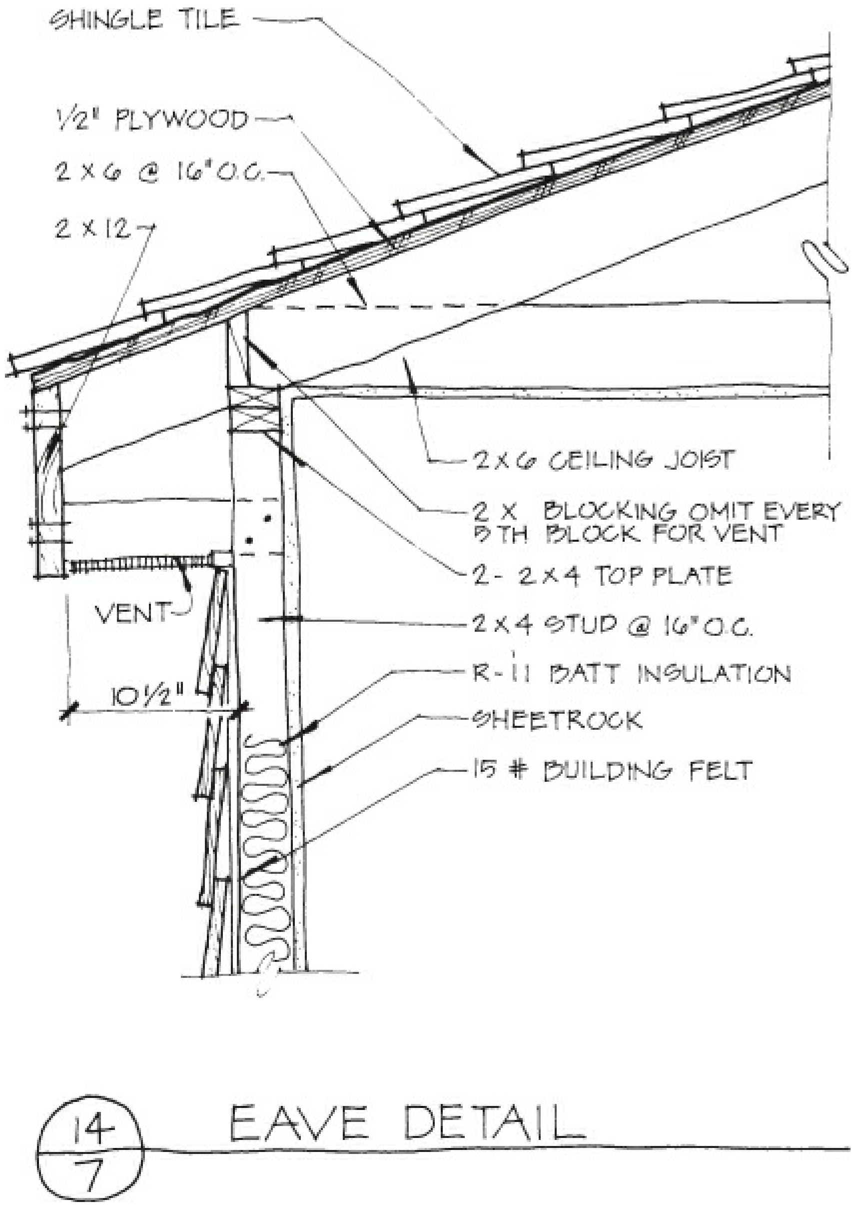


Figure 13.12 Eave detail.

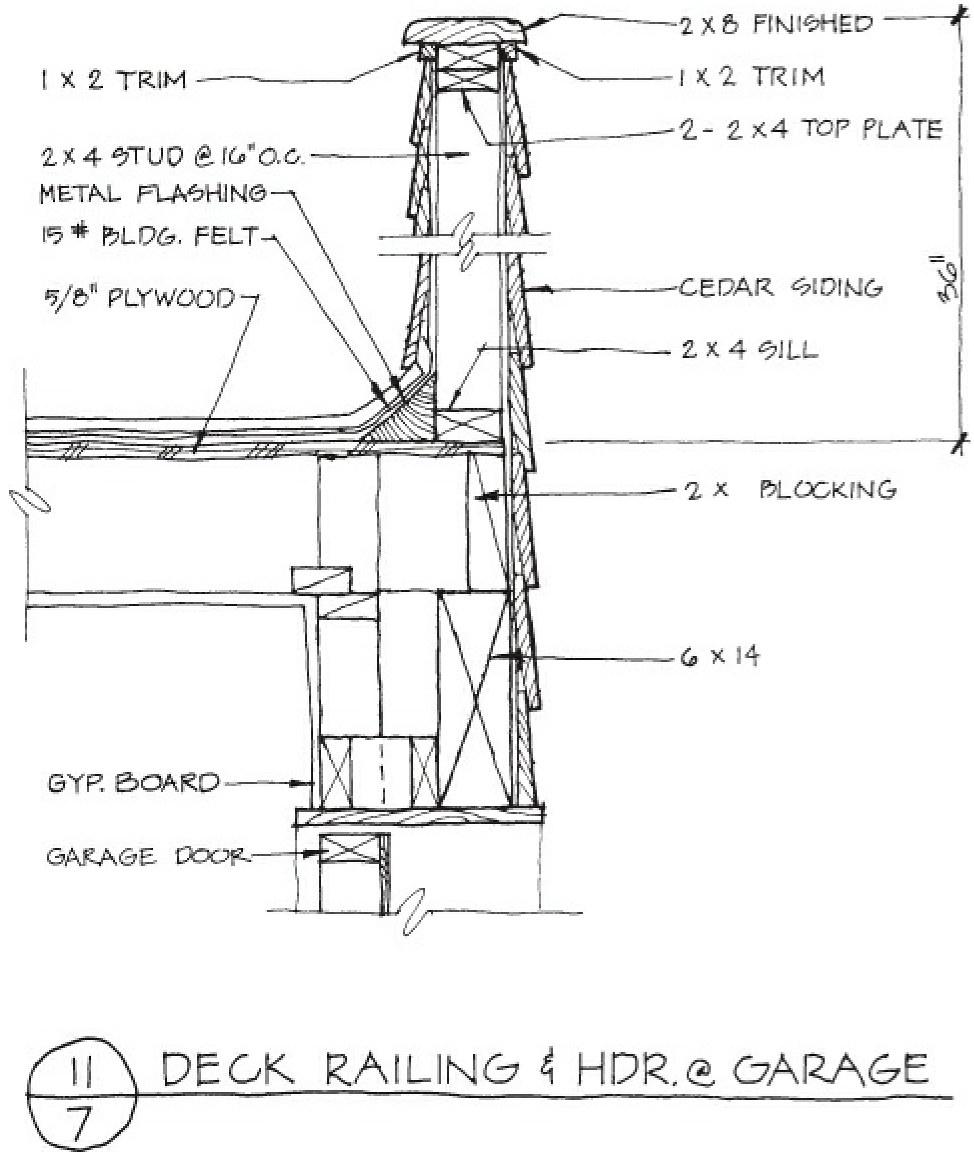
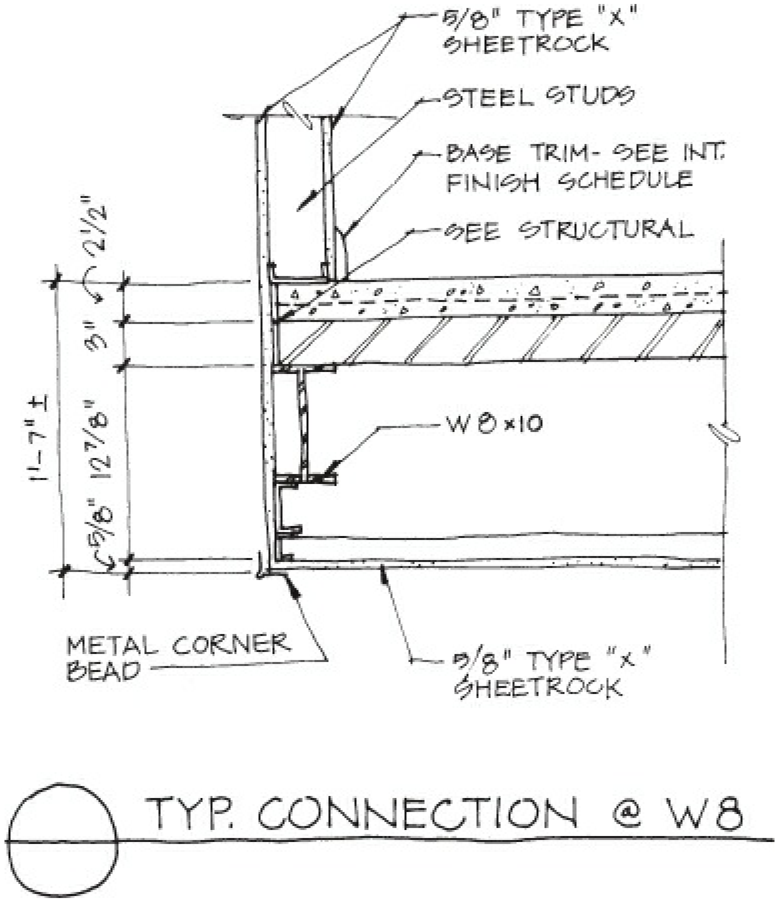


Figure 13.13 Detail of deck railing and header at garage.

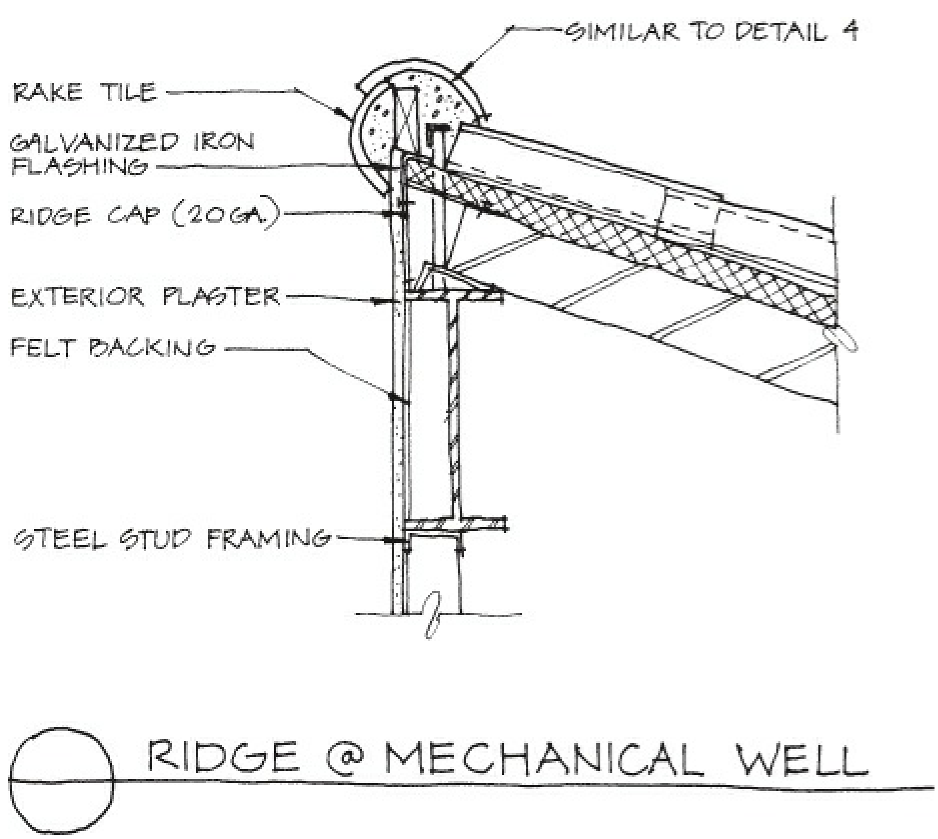
Details: Clay Theater

In some projects, such as the theater discussed in depth in Chapter 18, structural complexities may dictate various construction assemblies. For example, a masonry and steel structure has many architectural details that are governed by structural engineering requirements. The detailer must coordinate these details with the structural engineer. Figure 13.14 shows a detail for a steel beam connection, in which the beam, steel decking, and concrete…floor thickness have already been designed by the structural engineer. From these required members, the architectural detail is developed, showing wall materials, ceiling attachment, and under…floor space for mechanical and electrical runs. When critical information must be explained, or is explained on a separate sheet, the procedure is to add a note on the architectural drawing to "see structural." This refers the reader to the structural engineer's drawings, which provide such information as type and length of welds for steel connections, and size and weight of steel members. Note the call…out on the steel beam of "W 8 × 10." The "W" refers to the shape of the beam (here a **wide flange**), the "8" refers to the approximate depth of the beam (8 inches), and the "10" refers to the weight of the beam per linear foot (10 lb per linear foot).



[Figure 13.14](#) Detail of typical connection at a steel beam.

A second example is shown in [Figure 13.15](#). The steel stud framing is terminated at the bottom of the steel beam, and extensive galvanized iron flashing has been used to cover and protect the intersection of the various members at the ridge.



[Figure 13.15](#) Detail of ridge at mechanical well.

Some complex architectural details require much study before the finished detail can be drafted. The eave and column detail shown in Figure 13.16 is intricate and shows the entire column assembly from the foundation to the roof, including the eave detail. Notes refer the viewer to other details for more information. Usually, it is unnecessary and unadvisable to repeat all the information from one detail to another, as changes made on one detail must also be made on any other affected details and drawings.

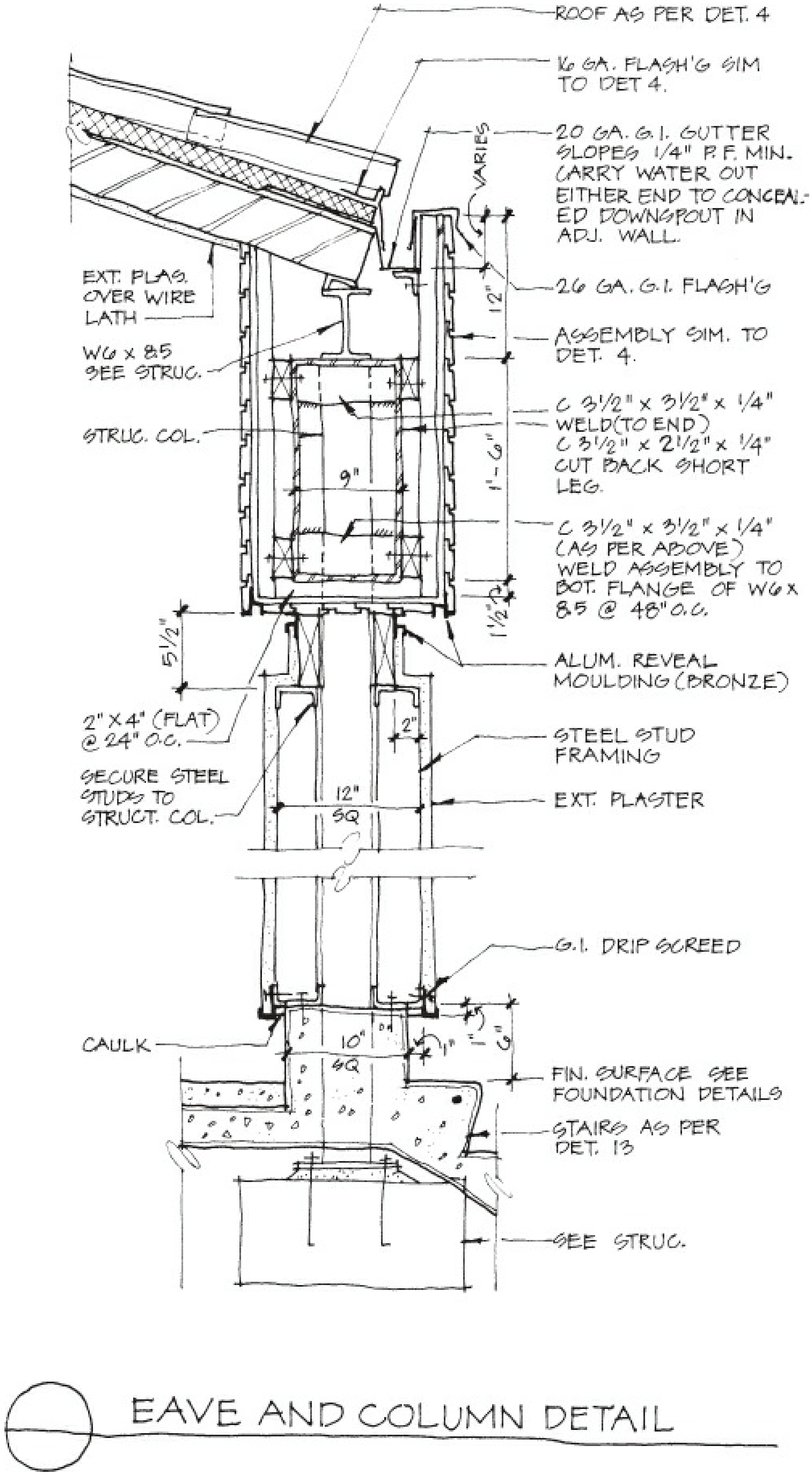


Figure 13.16 Eave and column detail.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings*, 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Many projects require a specific architectural detail to show conditions that will satisfy a

governing building code requirement. Figure 13.17, for example, shows exactly where a fire protection coating is required under a steel roof decking that covers the structural steel angle on a masonry wall. This information is combined with a roof parapet detail. Figure 13.18 shows another detail for areas requiring fire protection.

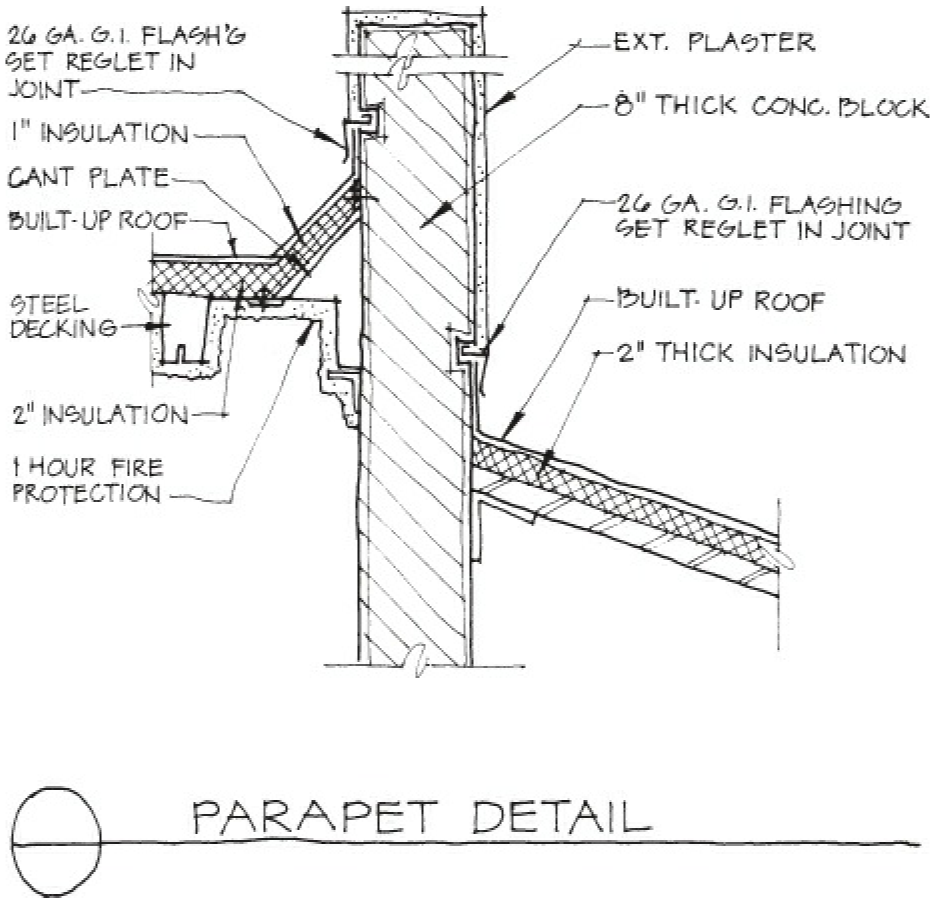


Figure 13.17 Parapet detail.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

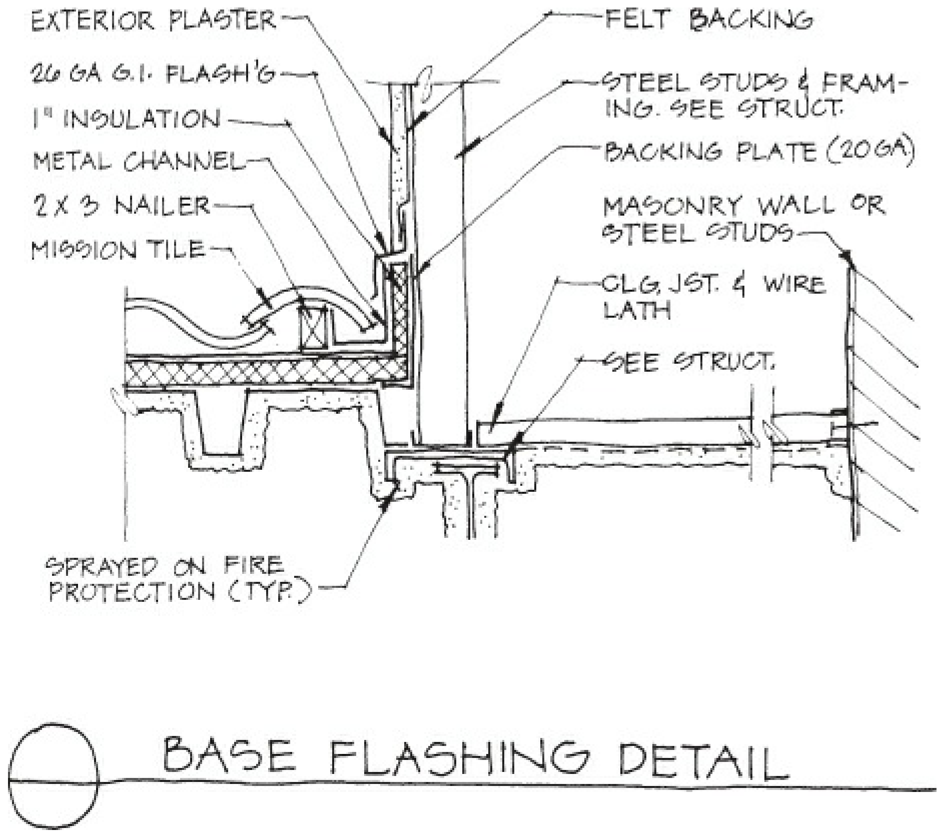


Figure 13.18 Base flashing detail.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

A third example of a condition requiring a detail is of a disability ramp, which must show the required number of handrails, the height of the handrails above the ramp, and the clear space required between the handrail and the wall. This information is combined with the structural requirements for the support of a low wall on the outside of the ramp.

Hard Line

Most books dealing with working drawings will begin with hard‐lined drafted details. Hundreds of details travel from office to office saved on a flash drive or e‐mail. Actually, this is a form of piracy that has been going on for years. Offices in the present day detail in a totally different manner, using a predrawn configuration that comes from a manufacturer which is easily in sized and incorporated into the detail sheet. Dimensioning comes next, and along with this, the head draftsman or production manager has thousands of prewritten notes to add to the detail, allowing the firm to maintain noting standards. Why, then, do the majority of architects and designers draw them freehand? It is a well‐known fact that drawing well and accurately freehand helps with eye‐hand coordination, not to mention one's ability to do accurate sketches for their clients or even sketching ideas for their colleagues or writing notes to their colleagues and their employees. These so‐called “sloppy notes” or illegible notes and indecipherable sketches have caused endless amounts of agony in the architectural profession.

Detailing is done freehand only at the conceptual level and confirmation stage to check whether, in fact, what was seen in the mind's eye really works. Freehand details are also

used as a means of communication from the mind of the designer to the real world of the drafter.

Approach to Detailing. Before you hard‐line draft a detail, you must understand its primary and secondary functions. Although functions vary, they may be categorized within a few divisions.

A. *Structural*. The intent of a detail may be to reveal the method of connection between two structural members or to show the transition between wood and steel members and the connective device to be used between them.

B. *Architectural*. The purpose of a detail may be to ensure that a particular architectural feature is explained, to maintain a certain aesthetic quality of a part of the building.

C. *Environmental*. A detail may reveal how to deal with environmental and natural forces, such as sun, rain, wind, snow, and light, as well as human‐made problems of noise, pollution, and so on.

D. *Human needs*. A detail may ensure that a particular human need is met. Stairs are a good example of this type of need, configured to allow a person to safely ascend or descend with the least amount of energy expended so as to avoid fatigue. This is done by formatting the proper angle of tread and riser. Special needs, such as those of elderly or physically impaired persons, are discussed in Chapter 2.

E. *Connection*. It is critical to detail a transition of one plane into another, for example, the connection between the wall and the floor or between the wall and the roof or ceiling.

F. *Material limits*. A detail may reveal the limits of the material with which you are dealing. You can drill a hole into a 2 × 6 floor joist, but how large a hole can you make before you weaken the member too much? The limits can be dimensioned or noted right in the detail.

G. *Facilitation*. In a tenant improvement drawing, a floor may be elevated to allow housing of computer cables. A detail can be drafted through this floor, showing the floor system support and the minimum clearances needed to accommodate the cables for maintenance.

Detailing Based on a Proper Sequence

Step 1. The drafter can accomplish the crucial **block‐out** stage by blindly copying the freehand sketch provided. Although this approach may be the most expedient, it misses two very important points: the drafter will never catch errors in the sketch, and the drafter becomes a tracer rather than a significant and valuable employee of the firm. Quickly outline the functional constraints of the detail, and check to see that the sketch complies.

Step 2. Once you have laid out the most significant form, you can now draw its adjacent parts. For example, in drafting an exterior bearing footing for a wood floor

system, do not draft the floor first and then add the footing; rather, draft the footing first as it is to be built.

Step 3. Add critical dimensioning.

Step 4. Strategically place notes so they clearly and easily convey the message.

Step 5. Designation of materials for the various pieces (wood, steel, earth, etc.) can be added at this point or at any of the previous stages.

Step 6. Profiling and **outlining** are almost synonymous. Darken the perimeter of the most important shape or shapes in the detail.

Step 7. Using the proper method described earlier in this book, add reference symbols, a title, and a scale so that each detail has an identifying "name" (title) and scale.

Shortcut. When details were drafted by hand, copies were often kept on file. A specific detail could then be copied, corrected by scissor drafting, recopied on vellum, and then put onto an adhesive that could be applied to the construction documents. Some offices may still follow this practice of working with details.

In offices that use computers, each detail produced in the architect's office can be archived and later retrieved when needed. These digital images can be changed to meet any new application needs.

Offices using computers and hand‐drafting prepared tracers with a minimal amount of information so that a drafter could later add new information to this so‐called **bare bones detail**. This practice is still used in some offices, but it is best done electronically. These bare bones details are developed, filed, and later retrieved as a datum stage to be updated with new and pertinent information.

Sizing Details. If you are working with a 24″ × 36″ sheet of vellum similar to that formatted in Chapter 3, and you extend the tick marks to form a matrix for detail placement, you will discover that the space measures 4⅝″ high × 6½″ wide. These spaces can be doubled in both width and height, or in both directions, depending on the scale of the detail.

With the availability of word processing and computer‐aided drafting (CAD), the drawing zone has been further subdivided into the drawing area and the note or keynote area. See Figure 13.19. The detail placed on one side allows the noting (done by CAD, word processor, etc.) to be done with ease. The drafter finishes the detail by drawing the leaders, thus connecting the notes with the drawing. See Figure 13.20. A further refinement is the use of **keynoting**. This refers to the practice of giving each note a number or a letter. When the detail is drafted, the leaders will use the corresponding number or letter pertaining to the note. See Figure 13.21. This method can be used by a manual drafter or by CAD, expediting the drawing procedure.

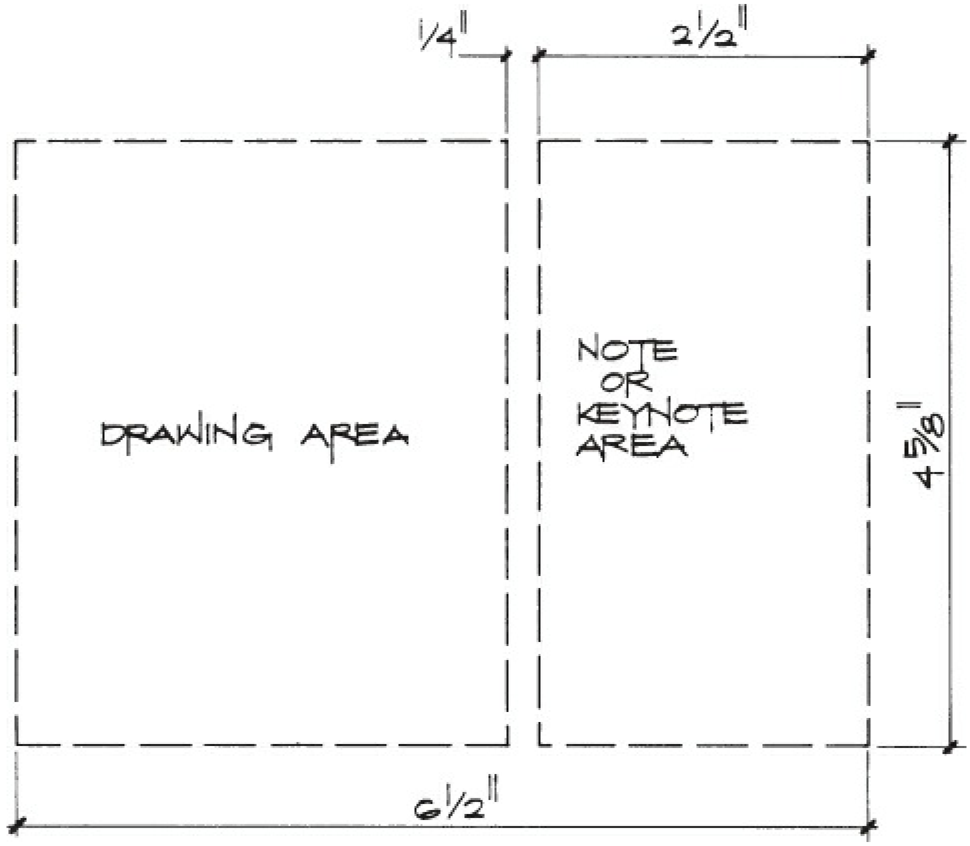


Figure 13.19 Detail format with noting area.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

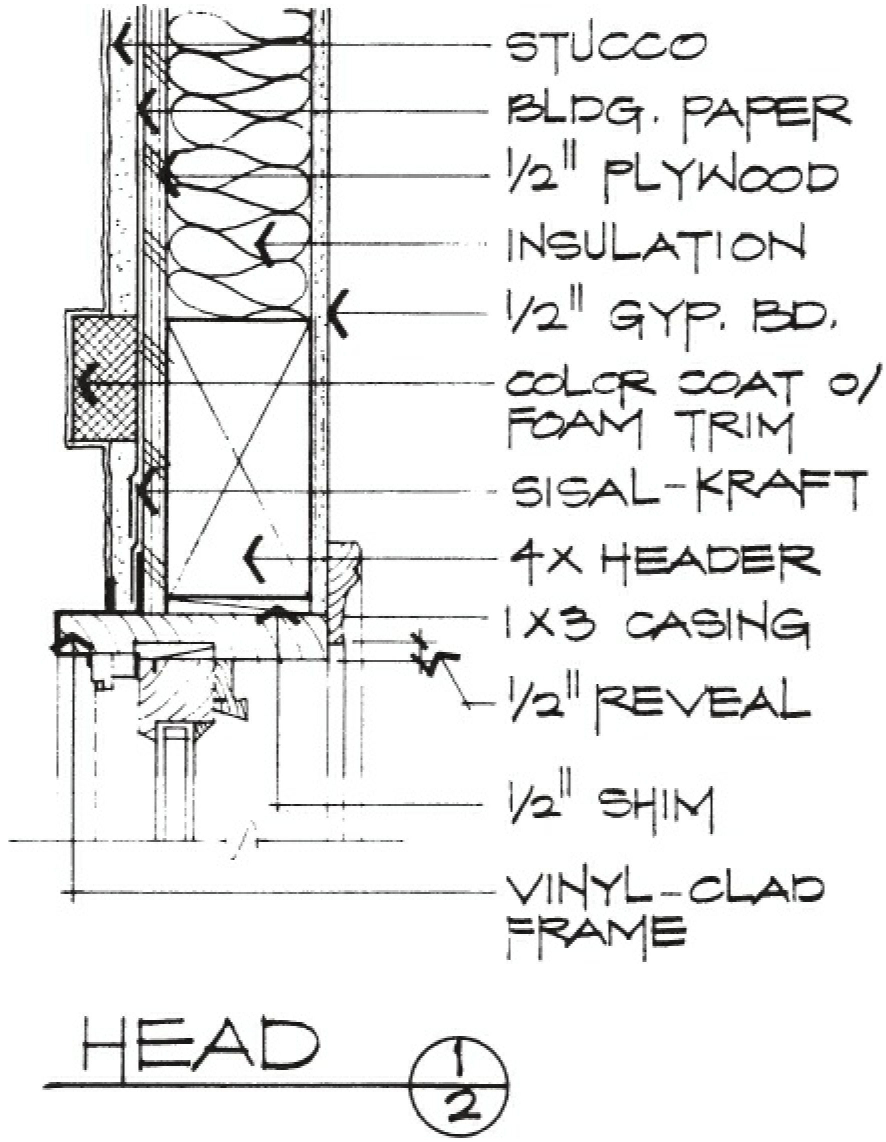
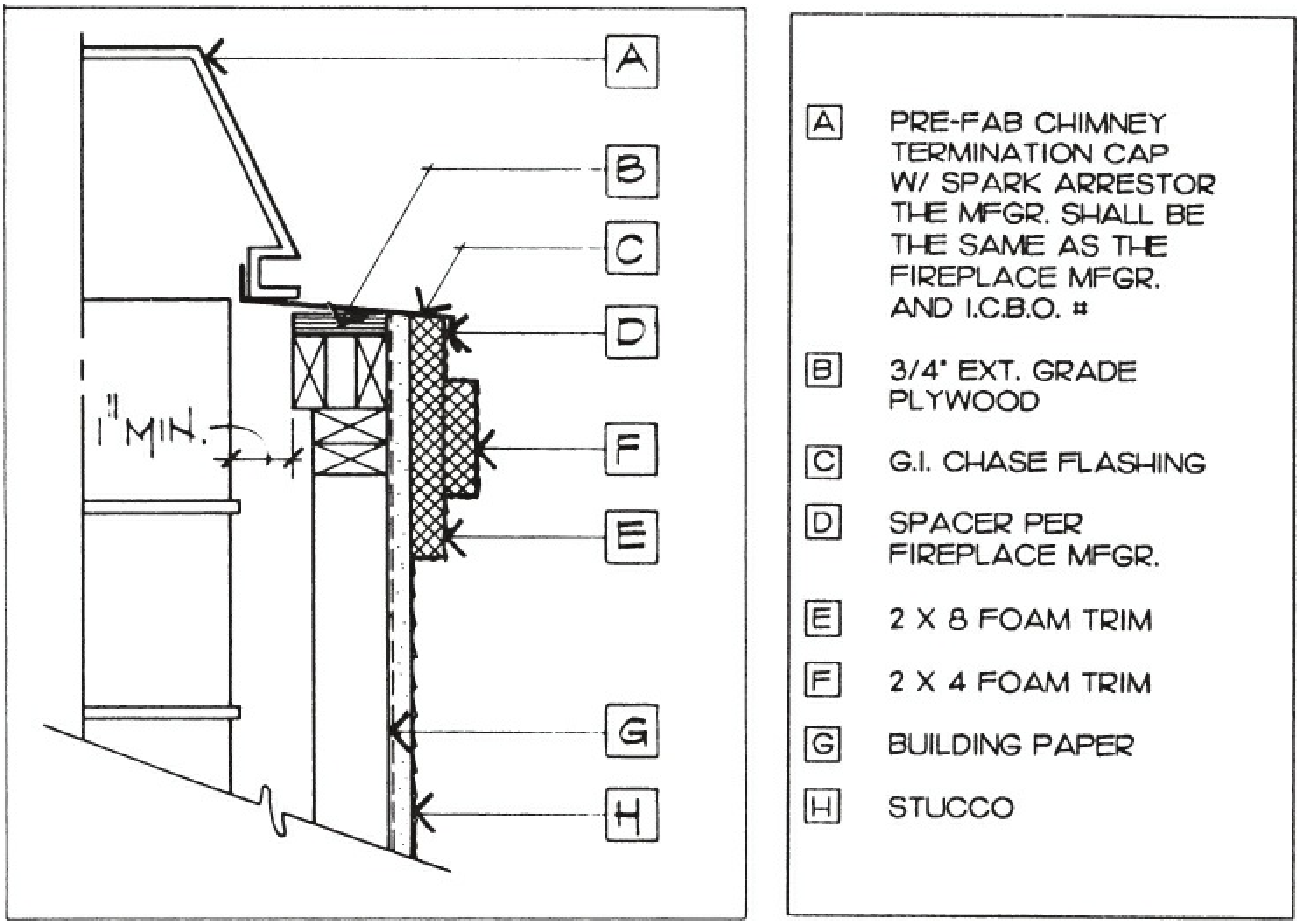


Figure 13.20 Window detail with noting format.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)



[Figure 13.21](#) Chimney detail with keynoting format.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Footing Detail. The exterior bearing footing for a residence is not unlike the freehand sketch found in Figure 13.9—but evolved. The difference between one footing and another can be so subtle that it takes a trained eye to distinguish them. As you compare the freehand detail with the hard…line detail shown in Figures 13.9 and 13.23 through 13.26, note the size difference at the bottom, the thickness of the foundation wall, the number of rebars, backfill, and sand versus gravel under the slab. These are two details that look alike but are really totally different in how they react to the various forces acting on them.

Before we hard…line the exterior bearing footing for the residence, let's look at four considerations for this type of footing.

A. *Configuration*. Most typically used is a two…pour, inverted "T" shape. Through the years, the industry has found this to be the best distributor of weight that uses the least amount of material. The inverted T distributes weight over a vast area. Notice how the weight from above is distributed on the soil in Figure 13.22A. Surrounding the example are dimensions: "X" is based on the weight of the structure and the ability of the soil to hold up this weight.

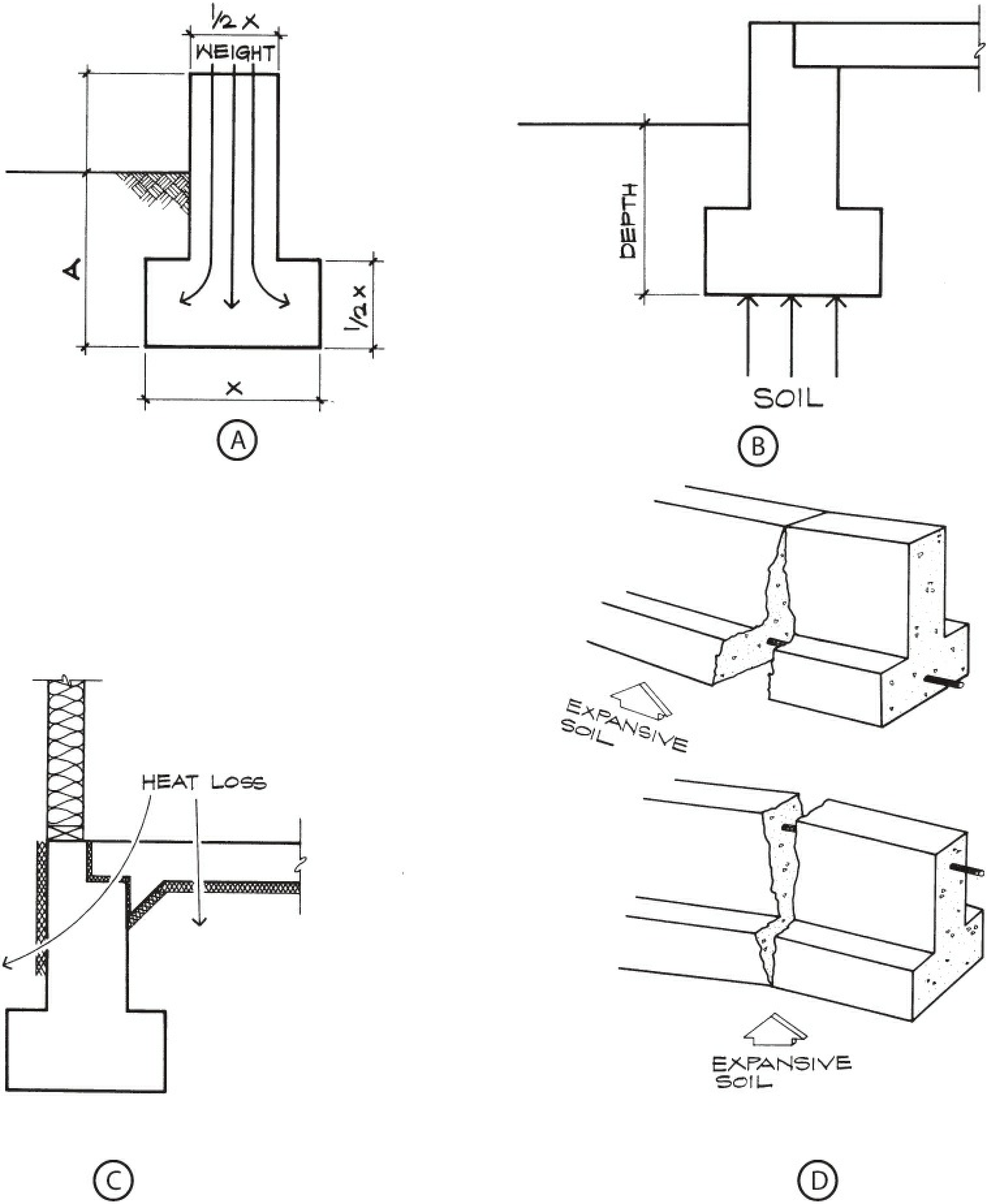


Figure 13.22 Footing concerns.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

As a rule of thumb, the thickness should be, as the example shows, ½X. The depth of

the footing, marked “A,” again depends on the stability of the soil or the frost line, or even a requirement of building officials, as a minimum. The prevailing attitude is, however, that rather than use established maximums, soundness of construction should prevail. The amount of the stem of the inverted “T” that extends above the soil might be a matter of how high it should be to keep moisture from the first piece of wood to come in contact with the concrete or to prevent termite infestation.

B. *Soil*. The cost of a piece of property might depend mostly on the view it provides, its convenience to various major streets, its slope, and so on, but many clients overlook the condition and quality of the soil. If a property has loosely filled soil (not permitted in many areas), the depth of the footing may have to extend far beyond the fill to firm soil, making the foundation very expensive. Moreover, in a marshy area where the **bearing pressure** of the earth (weight that can be put onto the soil measured in pounds per square foot) is minimal, the type and shape of the foundation may dictate a prohibitively expensive system, making the property impractical if not completely unbuildable. See Figure 13.22B.

C. *Strength*. Concrete, an excellent material with regard to **compression** forces, is very brittle in tension. The load imposed from above puts the concrete in compression, which is its strength. However, the footing travels the length of a wall, and with expansive soil or irregular loading, forms a beam that is in tension. This beam will break or shatter along the top or bottom, depending on the forces at work—thus the introduction of reinforcing bars, which are strong in tension, like a rope or chain, but rather weak in compression. By combining the two materials, we impart strength in both tension and compression. See Figure 13.22C.

D. *Energy*. In this era of energy…efficient buildings, architects are paying extra attention to areas through which heat is lost. The movement of heat, as any physics major will tell you, is from hot to cold. In colder weather, we must heat structures using whatever natural resources are available: natural gas, petroleum products, or in some cases electricity. To keep it from leaving the structure, heat is contained by means of insulating floors, walls, and ceilings. Notice the various possible locations for insulation on the footing in Figure 13.22D.

There are numerous other factors to consider in designing a footing. Where should the plastic membrane be put (if one is to be used)? Between the slab and the sand? Below the sand? How is the thickness of the slab determined? Does it require reinforcing? Backfill is still another factor—how much? The list goes on and on, always depending on conditions at the proposed building site. The answers to these questions relate to strength, energy conservation as a reaction to soil, and/or to the selected building shape, as mentioned earlier.

Exterior Bearing Footing (Residence)

Stage I (Figure 13.23). The grade line should be drawn first. This becomes the datum from which you establish all of the necessary vertical dimensions, such as the

distance to be placed between the floor and the grade. The width of the footing (**bearing surface**) is the next item to be measured. Half this width is centered for the stem wall. Footing thickness and slab thickness are positioned, and finally the beginning of the stud above the stem wall is drawn to create the slot for the slab.

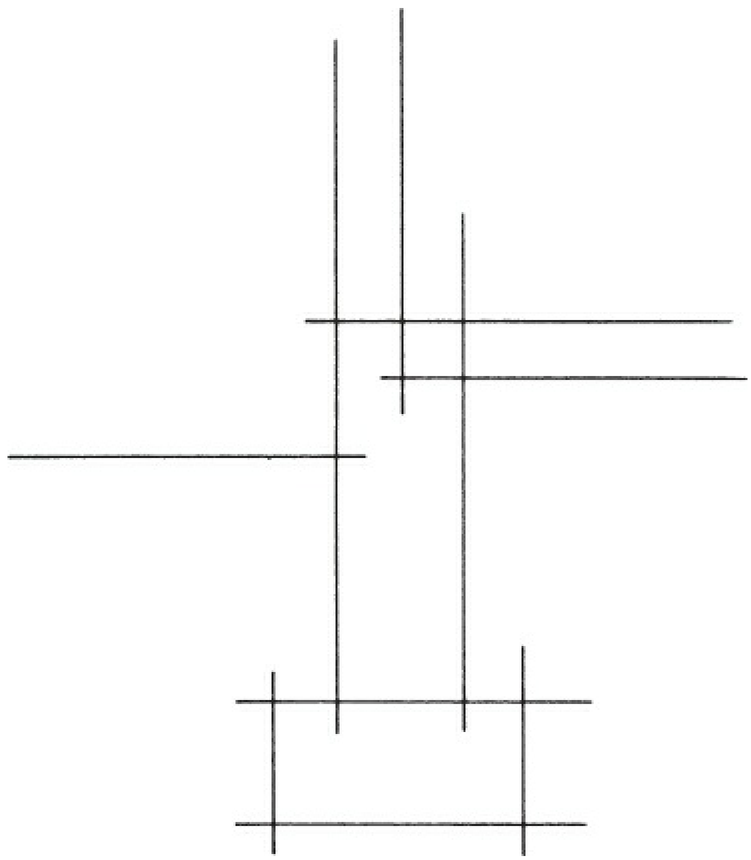


Figure 13.23 Stage I: Exterior bearing footing.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Stage II (Figure 13.24). After checking the accuracy of the first stage, proceed to the inclusion of the adjacent parts: insulation, sand or gravel, sill, the stud with its sheathing, and the termination points of the detail, which will be turned into break lines at a later stage.

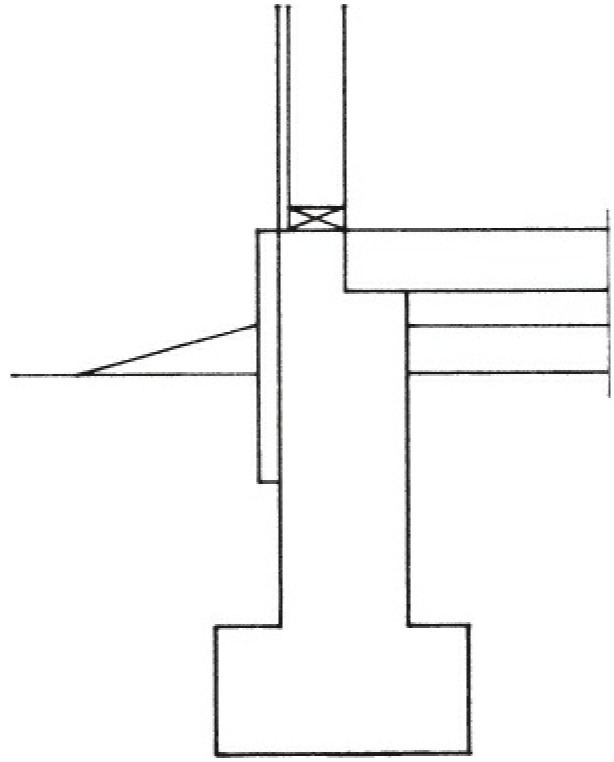


Figure 13.24 Stage II: Exterior bearing footing.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Stage III (Figure 13.25). This stage is actually a combination of Stages 3 and 5, dimensioning and material designation. Be sure to use the correct designation of material for each of the seven or so different materials used here: plywood, batt insulation, rigid insulation, concrete, rebars, and so on.

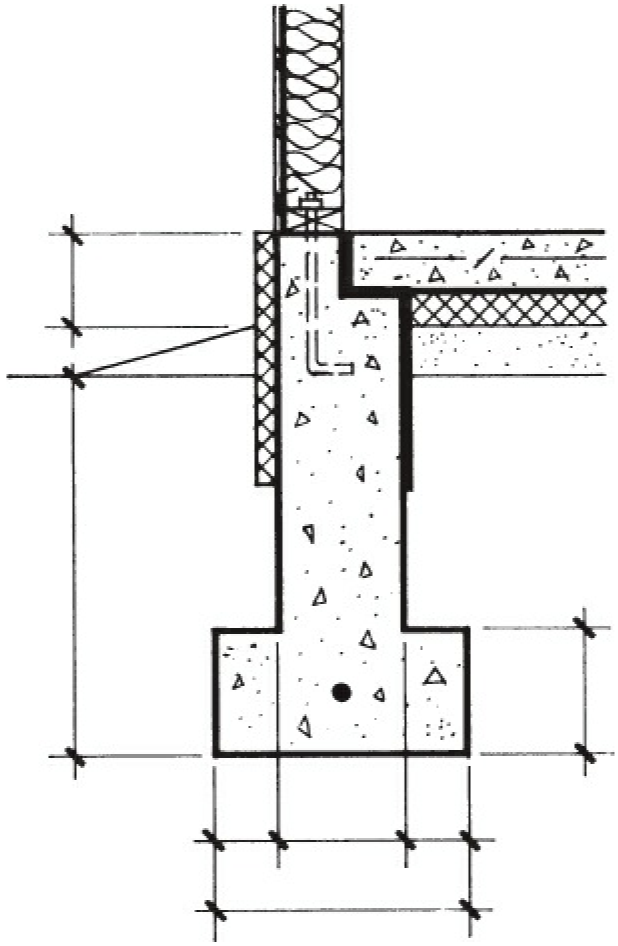


Figure 13.25 Stage III: Exterior bearing footing.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

Stage IV (Figure 13.26). This is the final stage, which includes additional profiling and noting. To keep the noting consistent from detail to detail, many offices have a standard set of notes. The project manager may select the proper notes from this standard list and make them available to the drafter. In other offices, especially small offices, this practice may not be used at all; rather, the drafter is presumed to have the necessary training and ability to note a detail properly. Detailing on a CAD system is merely a matter of recalling the proper notes, which have been stored in the computer, and positioning them.

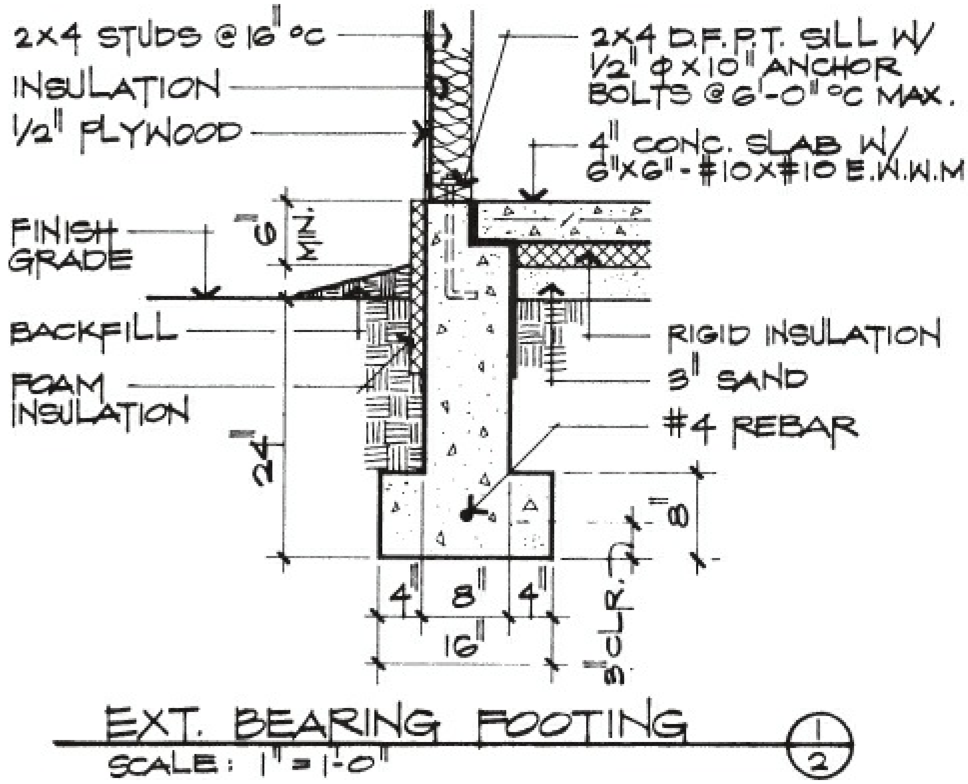


Figure 13.26 Stage IV: Exterior bearing footing.

(Reprinted by permission from *The Professional Practice of Architectural Working Drawings,* 3rd edition, © 2003 by John Wiley & Sons, Inc.)

If the notes are word processed, the drafter merely prints the necessary notes onto an adhesive and applies them to the drawing in the form of a chart called **keynotes**. See Figure 13.21. This procedure can easily be adapted to the computer as well.

Window Detail

Before drafting a window detail, the drafter should understand the action of the window's moving parts, its attributes, the installation procedure, and how to prepare the surrounding area before and after installation.

The window selected for our sample residence is an Atrium double…tilt window. See Figure 13.27. It was selected because it is not the typical double…hung, casement, or sliding window, and because of its special features.

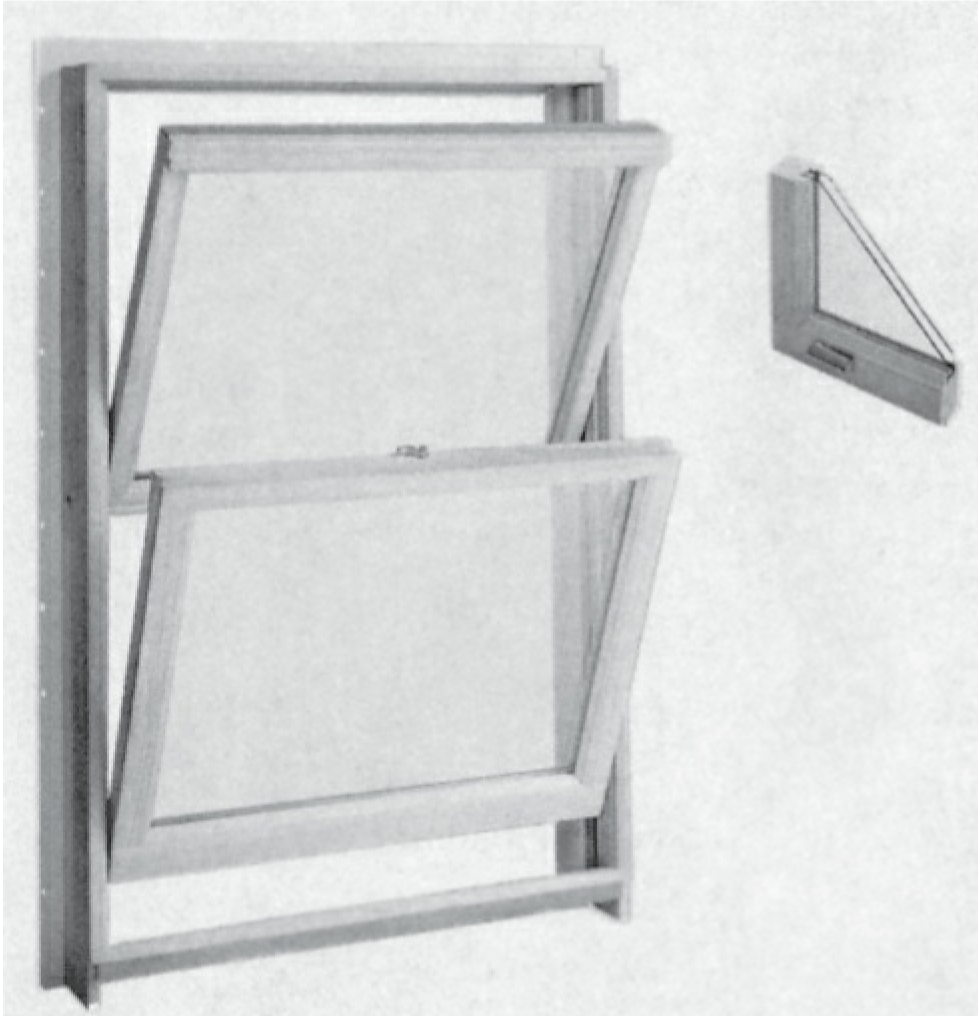


Figure 13.27 Atrium double‐tilt window.

(Courtesy of the Atrium Door & Window Company, a division of Fojtasek Companies, Inc.)

Weatherproofing

By studying the installation method, the detailer can better emphasize certain features of the detail. As seen in the original photograph (Figure 13.27), there are fins around the perimeter that are used to nail the window in place. Therefore, the rough opening (the rough framed opening) must have enough clearance to accommodate the preconstructed window. In this case, the clearance will be ½″ both vertically and horizontally, compensating for any irregularity in the framing members and allowing the window to be placed into the rough opening perfectly level. The wood shim under the windowsill in this sketch functions as a leveling device while sealing the space between the rough sill and the finished sill of the window.

Before and after the fin of the window is nailed to the wall, a moisture/vapor barrier is placed around the frame. The "Weatherproofing" section in Chapter 4 will acquaint you with the various materials used to waterproof windows and the reasons for the positioning of particular pieces of waterproofing material.

For the installation of this window, we use an asphalt‐saturated kraft paper to cover the building and a secondary strip (a band of about 6″–8″) of heavily saturated, heavyweight kraft‐type paper called **sisal‐kraft**.

In Figure 13.28, note the positioning of the building paper and its secondary member, the sisal…kraft. Both sheets are placed under the fin on the jamb and both sheets over the fin on the head. This strategic placement acts to shed water and prevent its penetration. This method is unique to Zone C (see the map in Figure 11.45).

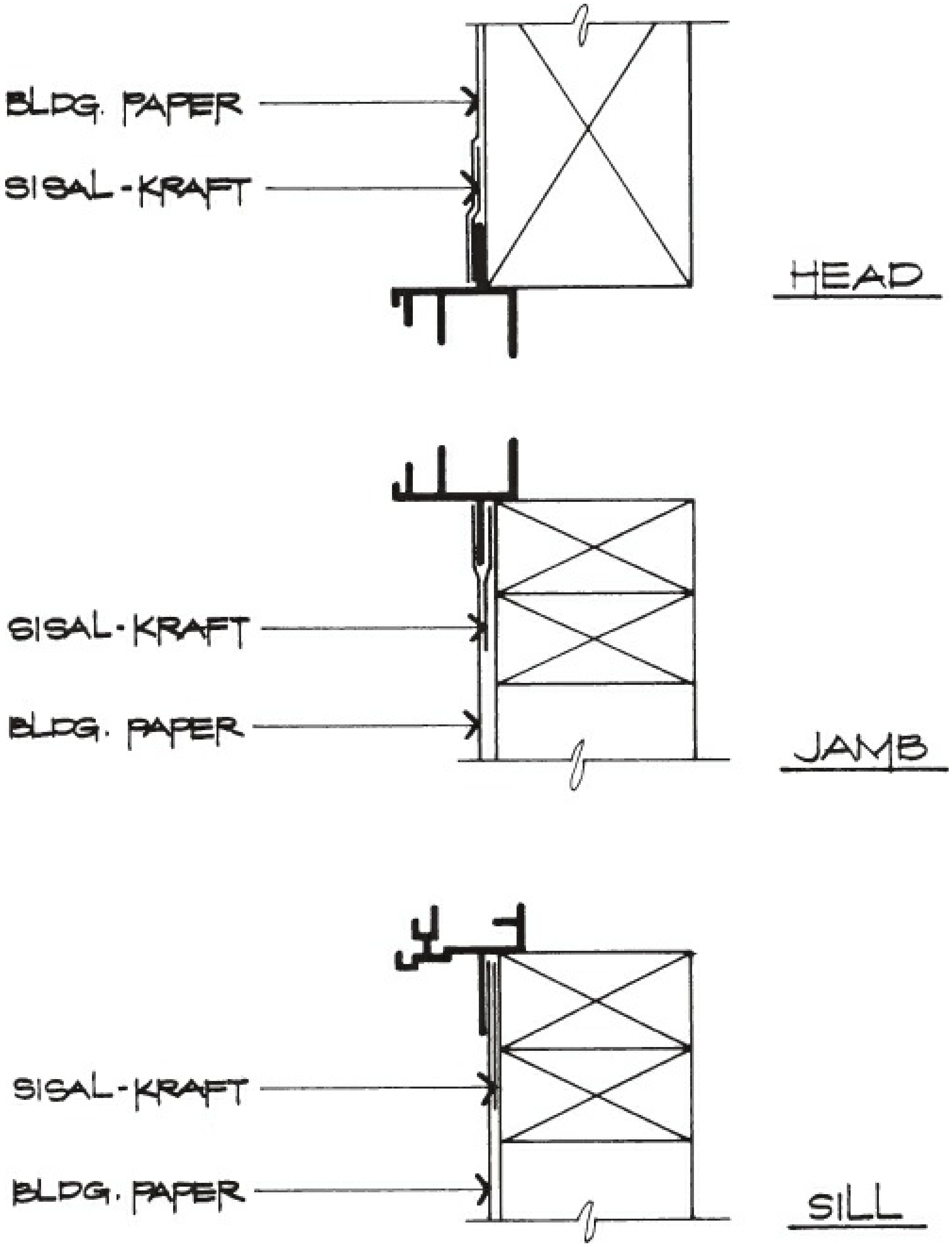


Figure 13.28 Placement of building paper around window.

Raised Frame

For this residence, there will be a raised plaster frame around each window. Such frames, called **stucco mold** (affectionately called **stucco bumps**), can be produced in a number of ways. Two possible solutions are described here. The first is to use one or more pieces of wood to raise the surface, as seen in Figure 13.29. Notice how the building paper is carried completely around the wood (including the metal mesh, which is not shown). The exterior plaster (stucco) follows the contour of the complete unit.

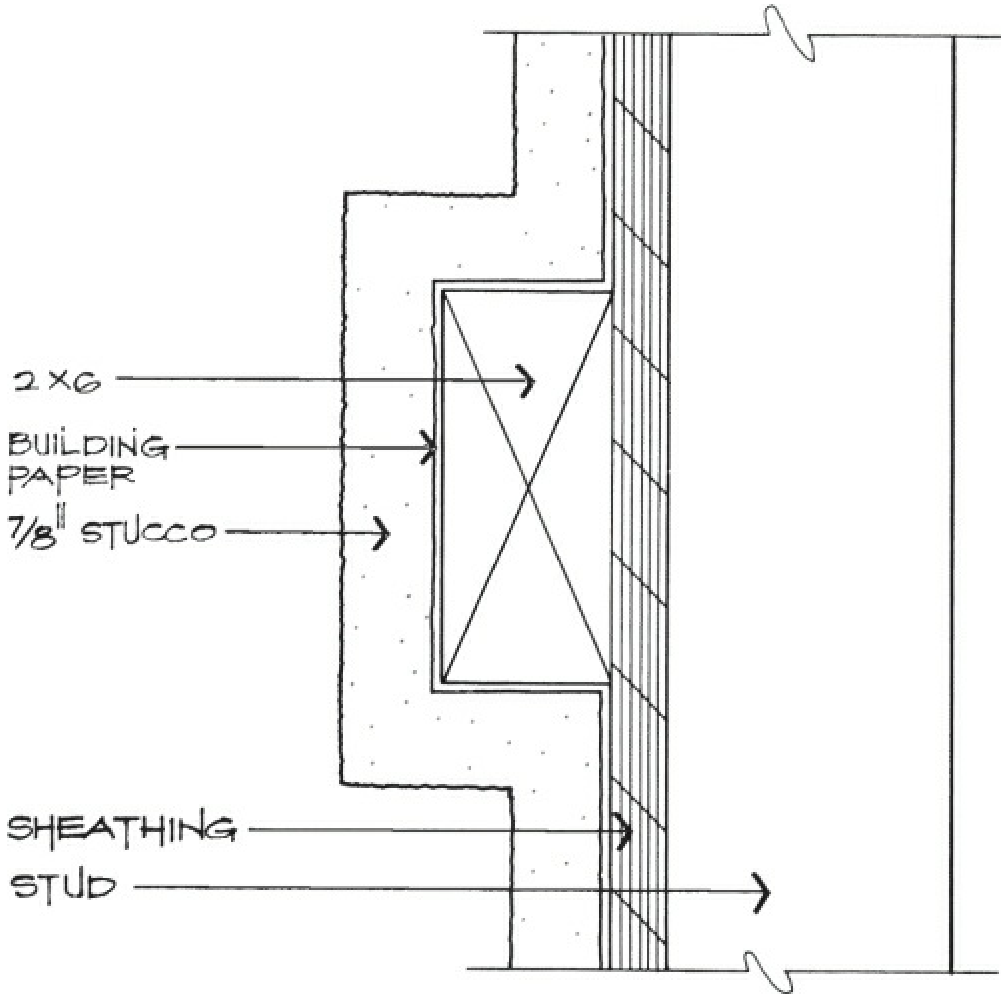


Figure 13.29 Raised surface using wood as a backing.

A second possible solution is the use of **Styrofoam**. See Figure 13.30. In this example, two pieces of foam have been placed over the first two coats of stucco, which are called the **scratch coat** and the **brown coat**. The final coat (called the **color coat**) is placed over the entire unit, completing the image as a whole. Notice the position of the building paper.

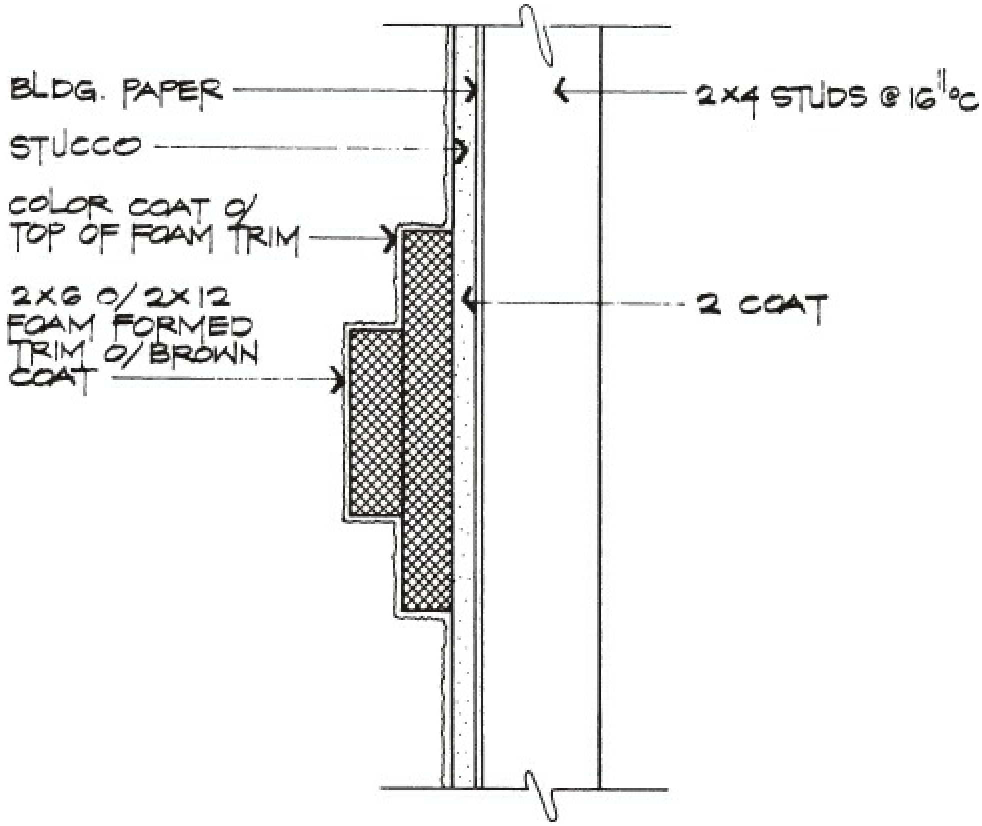
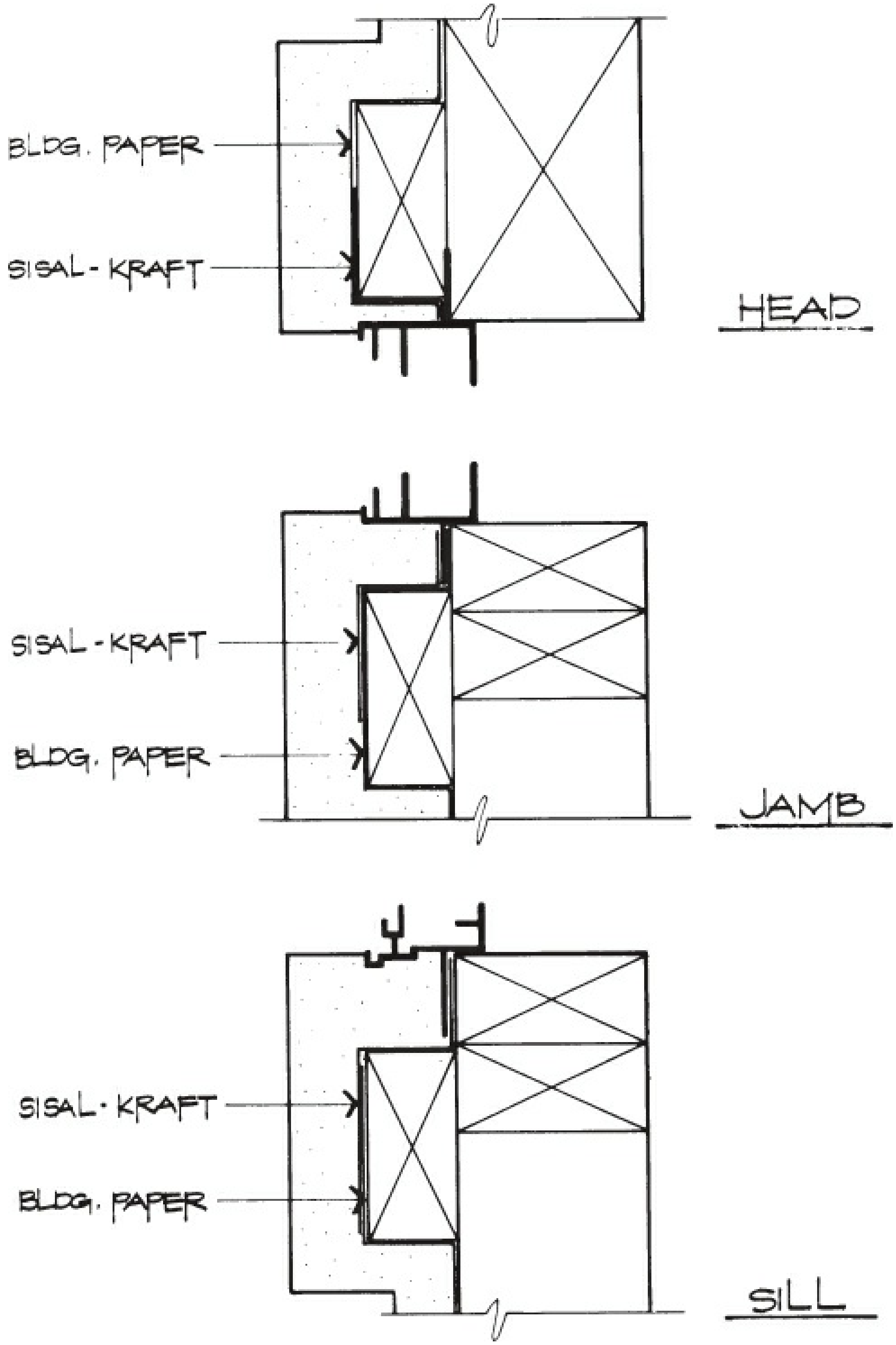


Figure 13.30 Raising a surface with foam.

For this sample residence, the second method is used and a keystone is placed at the top of the raised frame, as can be seen in elevation. Figure 13.31 shows the placement of the building paper and the sisal…kraft (called **counterflashing**).



[Figure 13.31](#) Raised frame of wood.

Rough Opening Size

Most manufacturers' brochures contain written descriptions of the window itself and its various features, the available stock sizes, suggested details depending on the context, and a drawing of the window at 3″ = 1′…0″ scale. For example, a DW2030 is really 19½″ × 29½″. Manufacturer drawings can be used as a tracer for hand…drafted, AutoCAD, or Revit details. Drawings can be downloaded; it is best to download the configuration of the window itself. Do not blindly use any suggested solutions, as the courts have determined that the manufacturer is not responsible for its performance. Instead, use the manufacturer's suggested drawings as a basis on which to adjust the drawing to meet

local codes and waterproofing/weatherproofing requirements. Be sure to adjust the manufacturer's window drawing to 3″ = 1′…0″. See Figure 13.32.

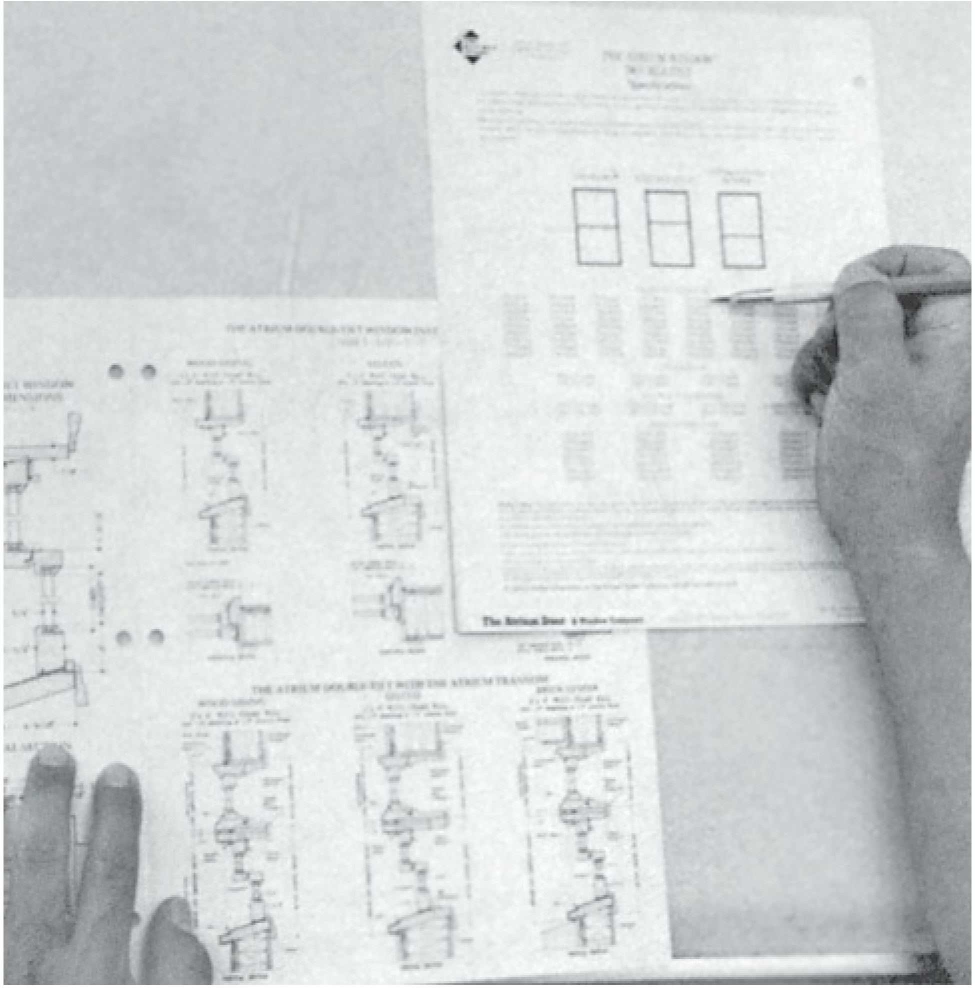
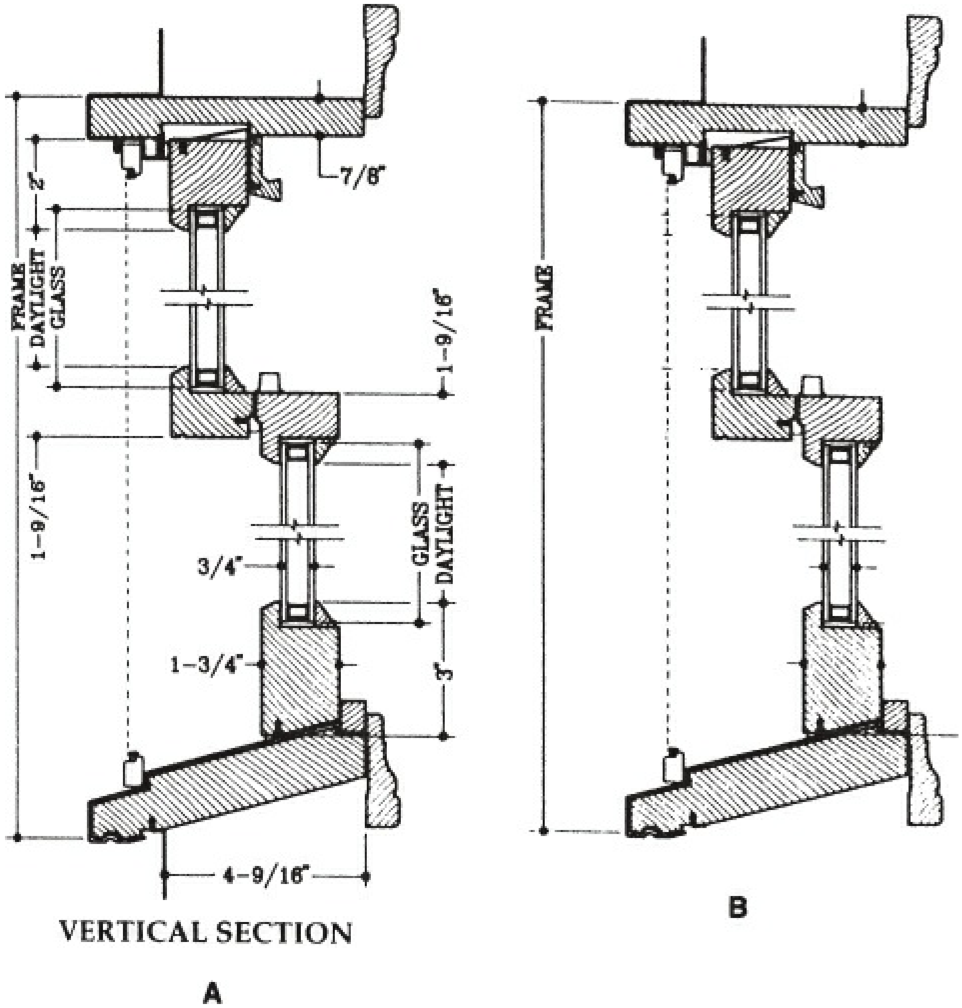


Figure 13.32 Rough opening sizes.

Window Detail (Residence)

Stage I (Figure 13.33) Actually, this is not a drawing stage, but rather a preparation stage. The 3″ = 1′…0″ vertical section provided by the manufacturer's literature is downloaded to the computer. See Figure 13.32.



[Figure 13.33](#) 3″ = 1′...0″ drawing by manufacturer.

Stage II ([Figure 13.34](#)). The rough framing is drawn on the drawing of the window. Care must be taken in redrawing any important line that was inadvertently eliminated or has faded away. The fin is especially important. Finally, the rough opening is established.

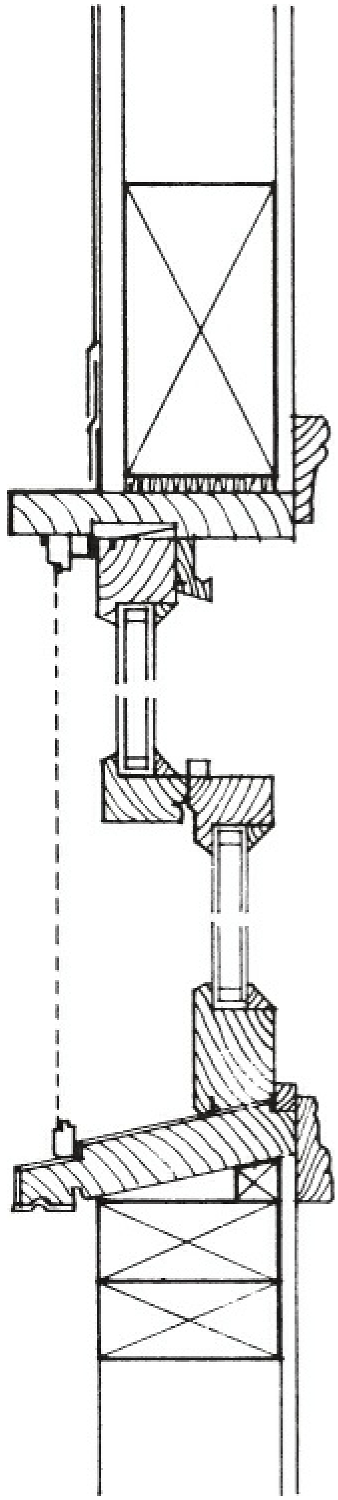


Figure 13.34 Laying out the rough frame.

Stage III (Figure 13.35). As we look at this detail, we should be able to see the lines of the jamb. To save time and for the sake of clarity, some offices do not put these lines into the detail. A true detail should include such lines, hence our choice to include them here. The interior and exterior wall coverings (skin) were drafted at this stage. Note the lining of the building felt over the fin for moisture control and the inclusion of insulation below the header. Finally, the raised window frame is drafted.

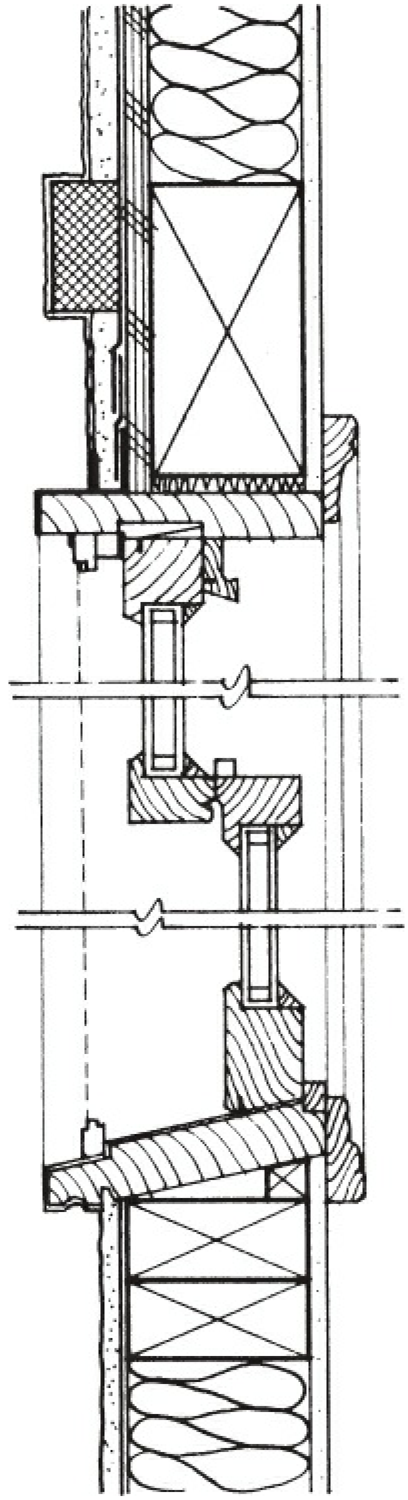
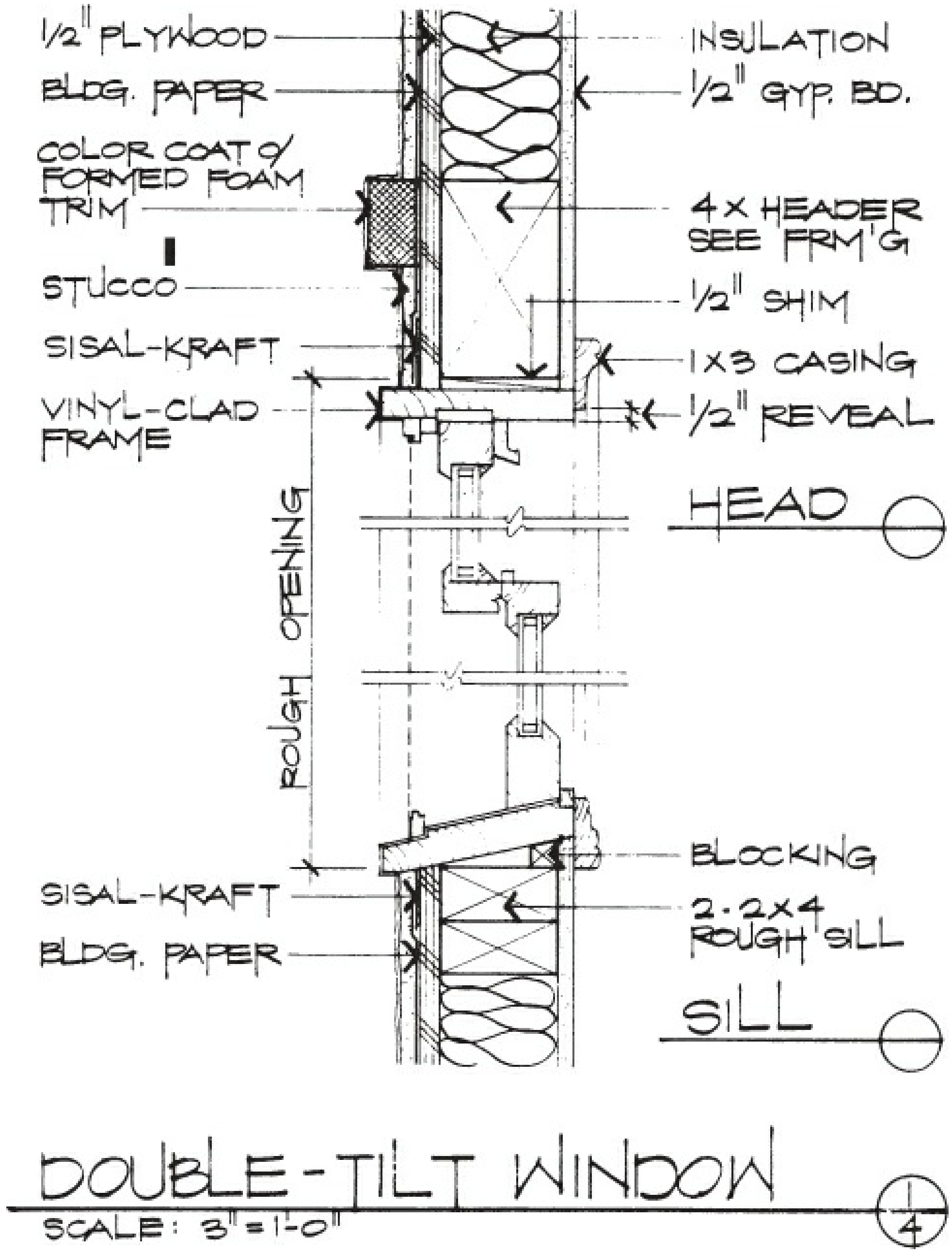


Figure 13.35 Applying the interior and exterior skin onto the wall surface.

Stage IV (Figure 13.36). Noting and referencing complete the detail. The positioning of notes is critical for ease of reading. Do not crowd the detail, but also avoid long leaders. Be sure to create a margin for uniformity of appearance. The detail style is referred to as **freestyle**, with noting scattered around the perimeter. A better method would be to use the keynoting mentioned earlier in this chapter.



[Figure 13.36](#) Noting and finishing the window detail.

Fireplace. Fireplaces have gone through quite an evolution over the past century: from masonry fireplaces, which are still built, to metal; from fully vented fireplaces using chimneys to those that have no vent at all. Some varieties burn wood as fuel; others burn natural gas or, more recently, gelled alcohol. Wood…burning fireplaces are not allowed by some municipalities.

Fireplaces can be built to use remote control starters (much like those used for a television). They can also be constructed to recirculate warm air. Fireplaces can be made to look like fireplaces or designed to look like furniture. Portable fireplaces, which burn gelled alcohol, can be moved from room to room, much the way furniture is rearranged. When you move, you take the fireplace with you.

Many metal fireplaces are fitted with pockets for recirculating air. The air around the fire chamber is heated and redirected back into the room. You can even have a thermostat…controlled blower installed, which increases the movement of the warm air, thus

achieving greater efficiency in heat circulation. This means that 20,000 to 75,000 Btu/hr of heat can be recaptured. See Figure 13.37.

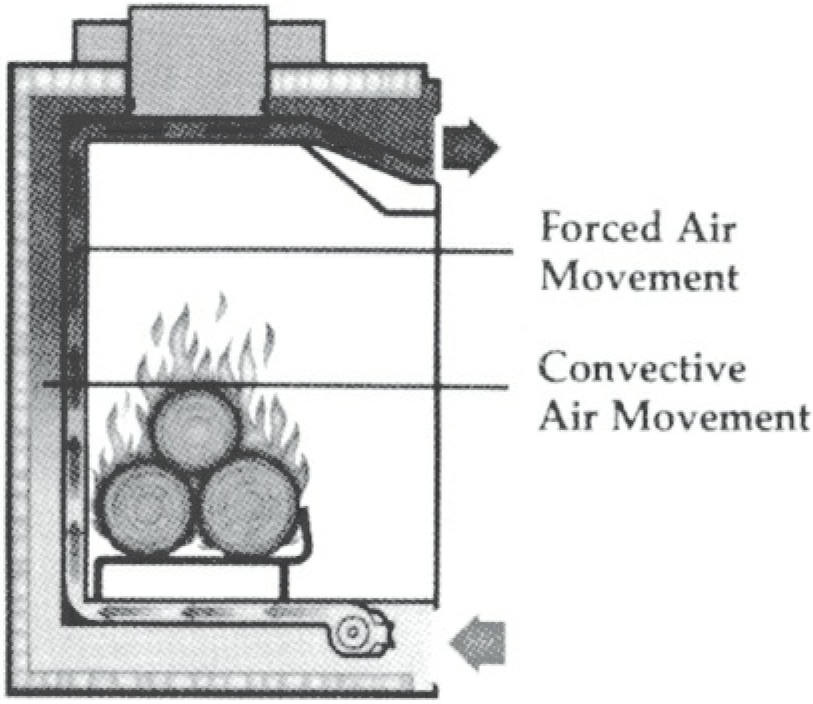


Figure 13.37 Heat circulation.

(Courtesy of Majco Building Specialties, LP.)

For the sake of this discussion, fireplaces are categorized as follows:

Standard fireplace. The normal masonry units that are usually job…built and require the detailer to draft the fireplace from the throat. Often built of concrete block, brick, or stone.

Prefabricated fireplaces. Built of steel, with the chimney built of double… or triple… wall units that snap together. A typical unit can be seen in Figures 13.37 and 13.38.

Figure 13.38 Majestic heat‐circulating fireplace.

(Courtesy of Majco Building Specialties, LP.)

Direct‐vented fireplaces. Built of steel and similar to the prefabricated fireplaces previously described, except that they are vented directly out an adjacent wall. See Figures 13.39 and 13.40. Note the uninterrupted windows surrounding the fireplace in the photograph.

Figure 13.39 Majestic wall‐vented fireplace.

(Courtesy of Majco Building Specialties, LP.)

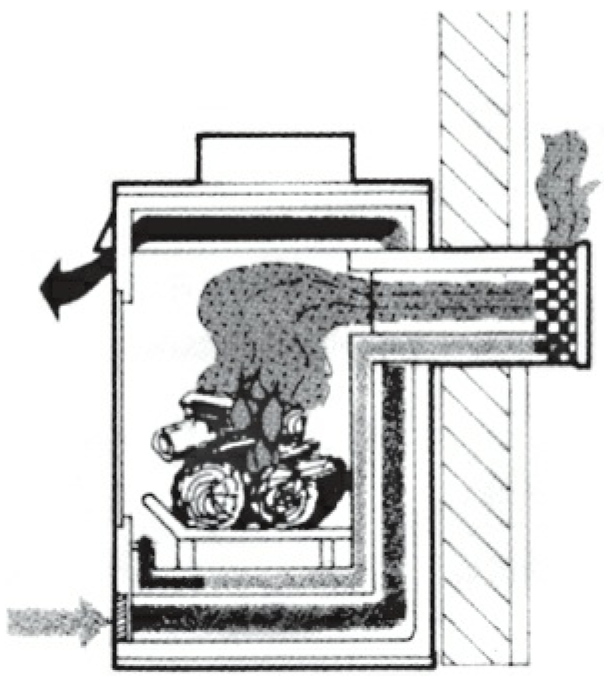


Figure 13.40 Wall‐vented schematic.

(Courtesy of Majco Building Specialties, LP.)

Portable fireplaces. Made of metal and built much like an oven, so that the outer surface gets warm but not hot to the touch. Can be housed in a cabinet like a

television set, and uses a clean…burning gelled alcohol.

Fireplace for a Residence

For a residence, the Majestic 42 unit was selected for its heat…circulating features. See Figure 13.38.

Much like the Atrium window discussed earlier, this fireplace has a metal fin (tab) around the perimeter of the front face that can be nailed to the surrounding framing. The metal fireplace must not come into contact with the framing around it. The manufacturer suggests a minimum clearance of about ½″, but the local codes should be checked.

The chimney is a triple…wall unit and does not necessarily go straight up through the ceiling and/or roof. Bends of 30° can be incorporated as the chimney goes through the space provided. This space, called the **chimney chase**, allows the chimney to pierce the ceiling or roof at a convenient point, so as not to interrupt the plane of the roof at an intersection (such as a valley) or to bypass a beam or other structural member. See Figure 13.41. Straps are then used to stabilize the chimney to the adjacent framing members. See Figure 13.42. Note the inclusion of a recommended 2″ clearance space.

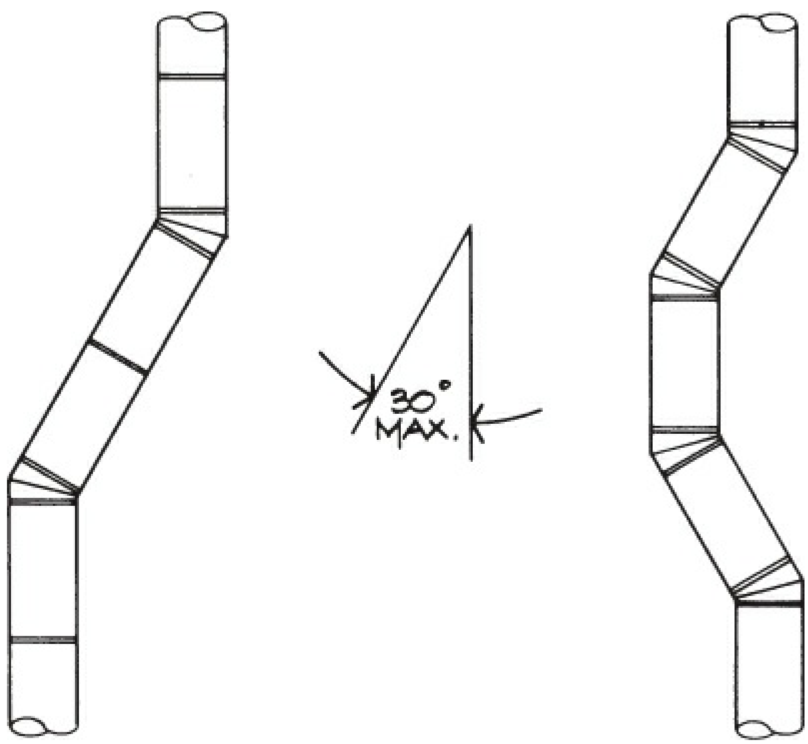


Figure 13.41 Bends in chimney section.

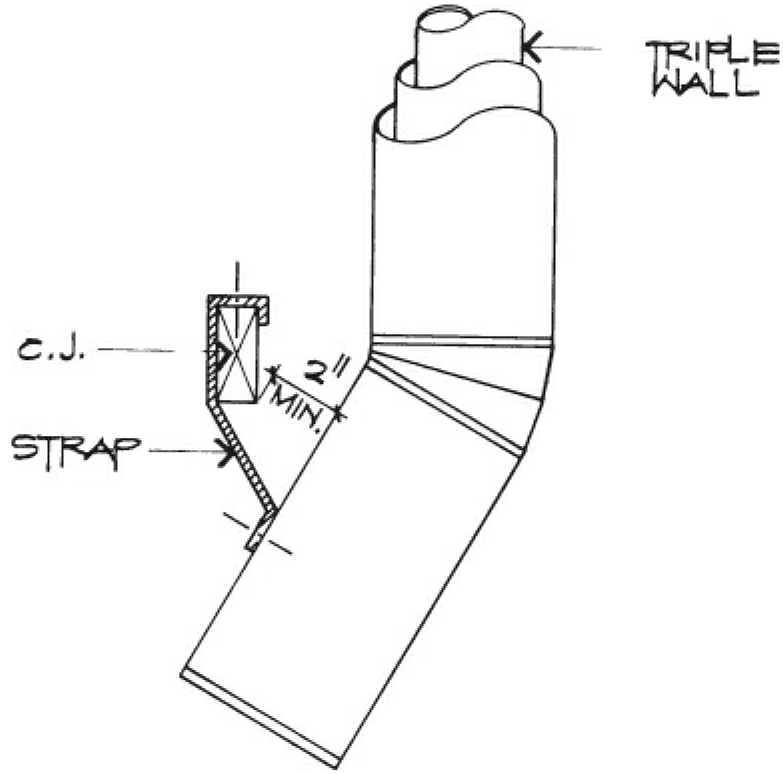


Figure 13.42 Chimney attached to adjacent members.

A firestop spacer should be used on top of the ceiling joist or on the underside of the roof joist when there is an attic space. See Figure 13.43.

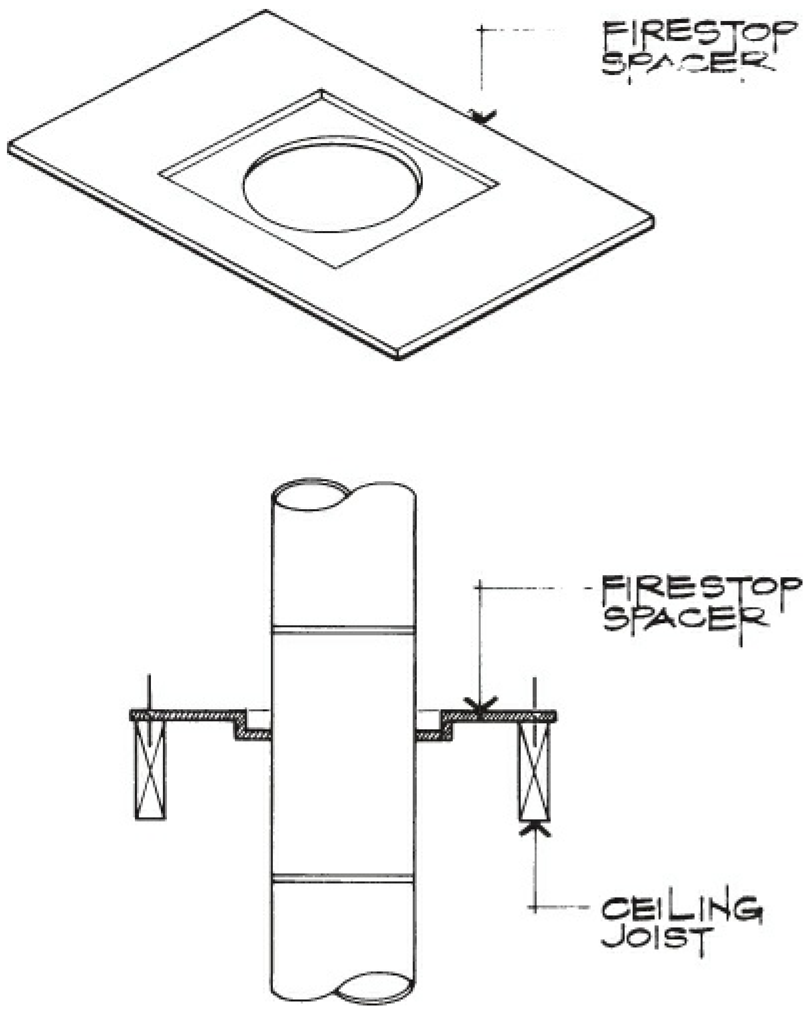


Figure 13.43 Chimney position.

The total area around the opening (**chase**) should be insulated even if the wall is an inside wall. If the fireplace is on a second floor or on a first floor constructed of wood, the space under the fireplace should also be insulated. In fact, it is always best to read the installation manual before detailing the framework around the structure. The detailer should not worry about how the smoke is drafted out of the fire chamber or the inner workings of the fireplace, because the fireplace engineering has already been done by the fireplace manufacturer's designers.

Framing

The walls around a prefabricated fireplace are framed in the same way as all other walls. Even the opening for the fireplace is framed in the same manner as other openings, such as doors, skylights, windows, and so on. See Figure 13.44.

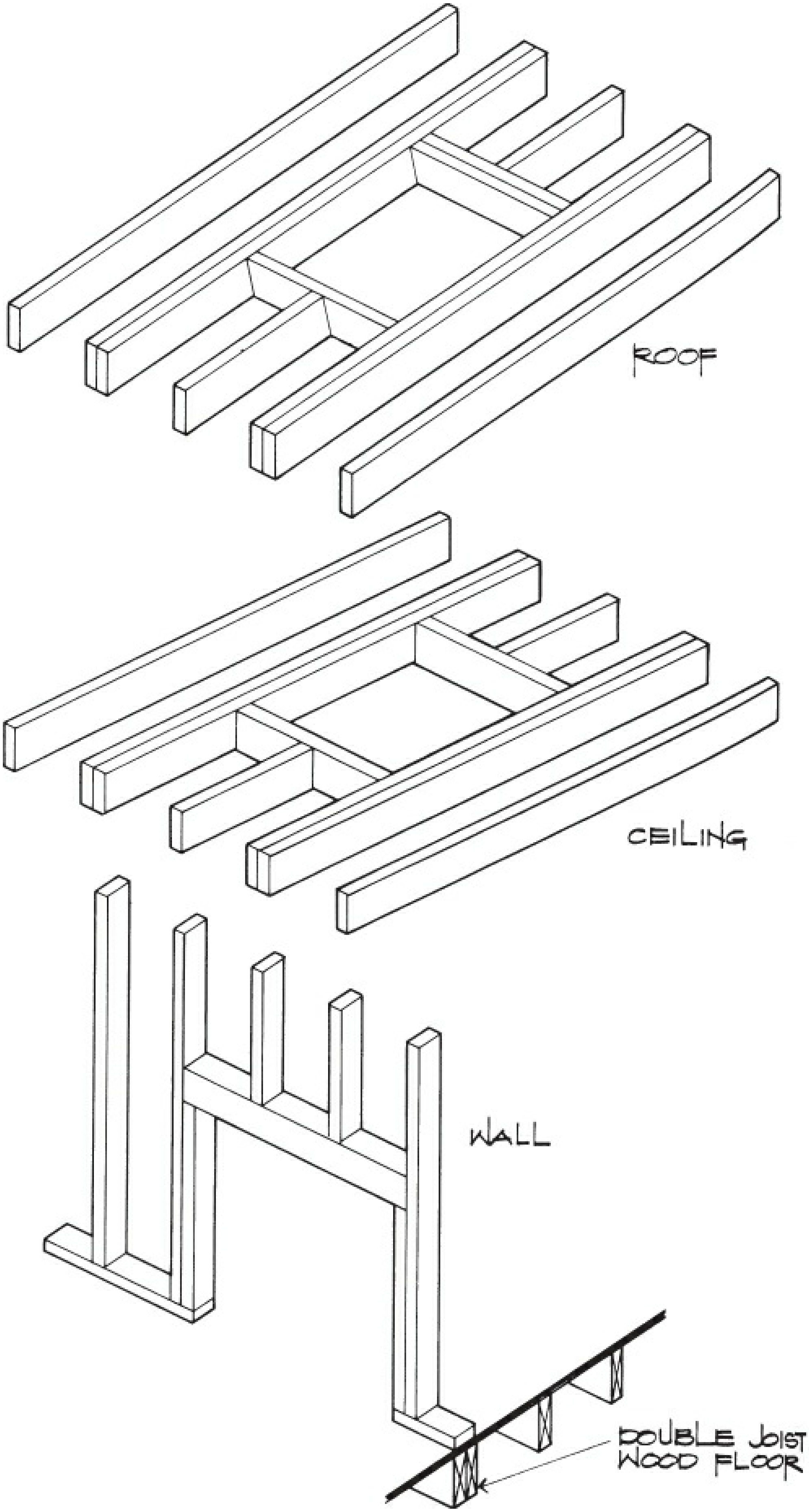


Figure 13.44 Framing an opening.

The framing on a residence is unique because:

A. The fireplace is backed against a bearing wall.

B. The rafters of the main part of the roof will come down to the bearing wall.

C. The ceiling joists run perpendicular to the main rafters.

D. A California framed roof must also be reframed with an opening. **California frame** is a framing process in which the major zone (see Chapter 5) of a roof is completely framed first and joined by the minor zone. Each form is built completely into itself and later integrated with the other zones/forms.

E. The chimney will be contained inside a wood chase and capped with metal.

See Figure 13.45 for a model simulation of this area and Figure 13.46 for a full section of a fireplace.

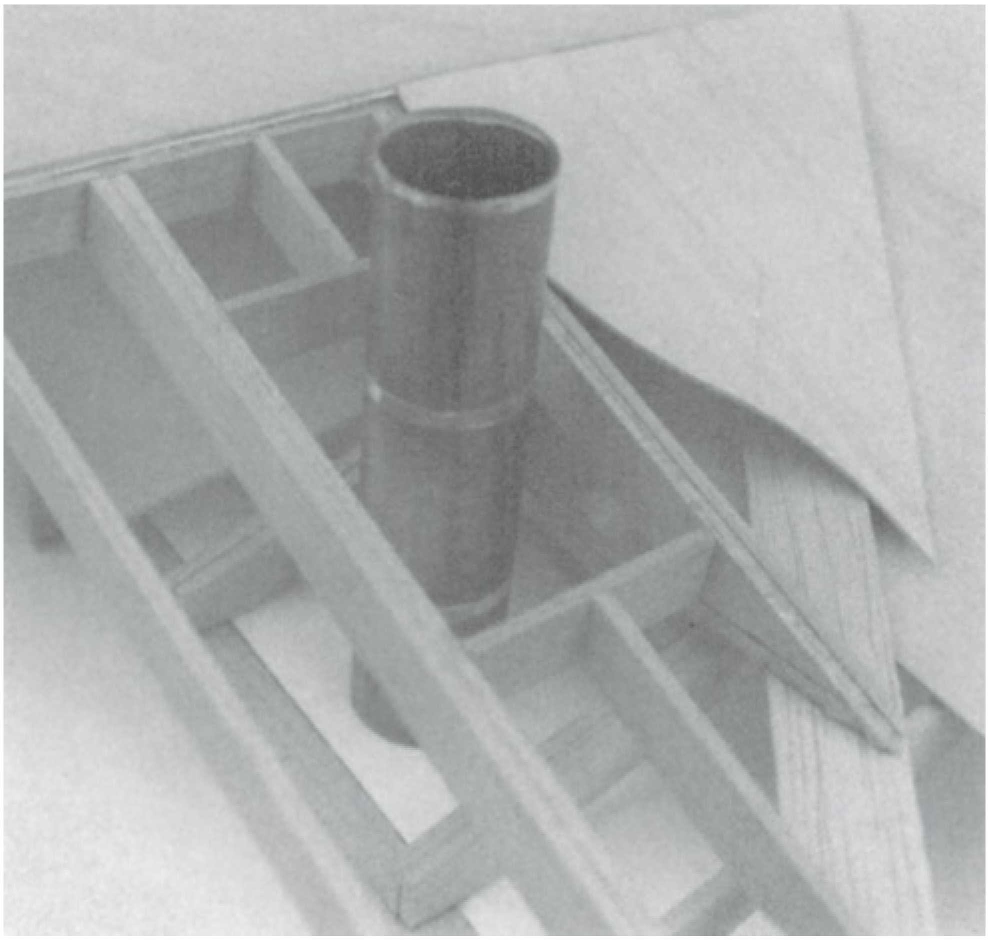


Figure 13.45 Model simulation of the framing through the roof.

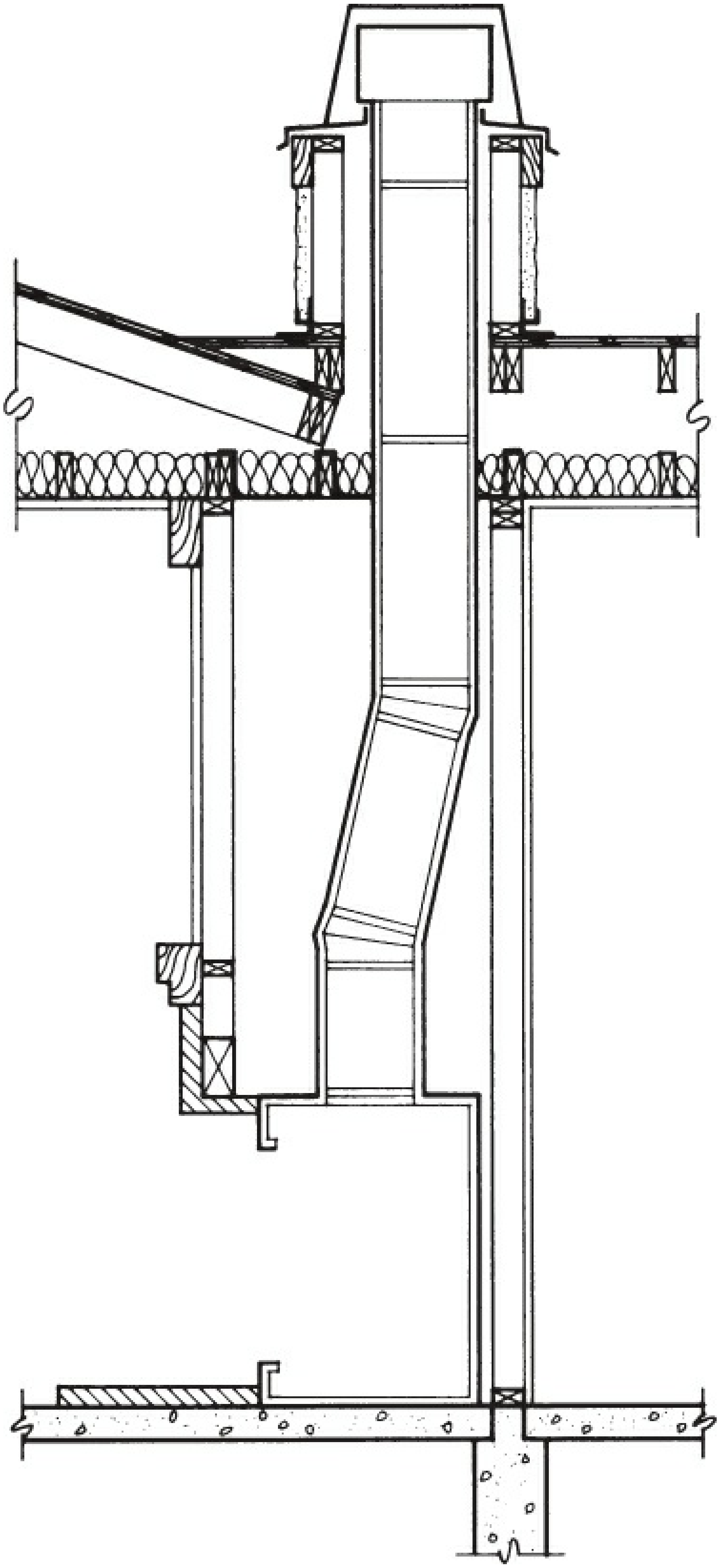


Figure 13.46 Full section of a fireplace.

Chimney above Roof

In most cases, a chimney must rise 2 feet higher than the highest part of the roof within a 10…foot radius. See Figure 13.47.

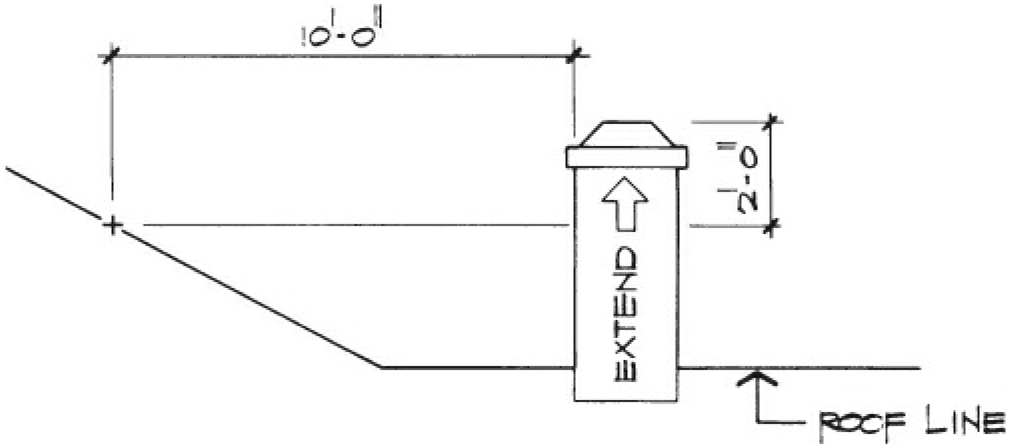


Figure 13.47 Chimney above roof.

Chimney Chase

There are a number of ways of terminating the chimney above the roof. A round top termination, as seen in Figure 13.48, can be used to “top it off,” and the finish will be left in this state. A second possibility is to purchase a constructed metal chase to cover this metal termination. A third suggestion is to use a wood chase with an Underwriters Laboratory (UL)…listed constructed cap.

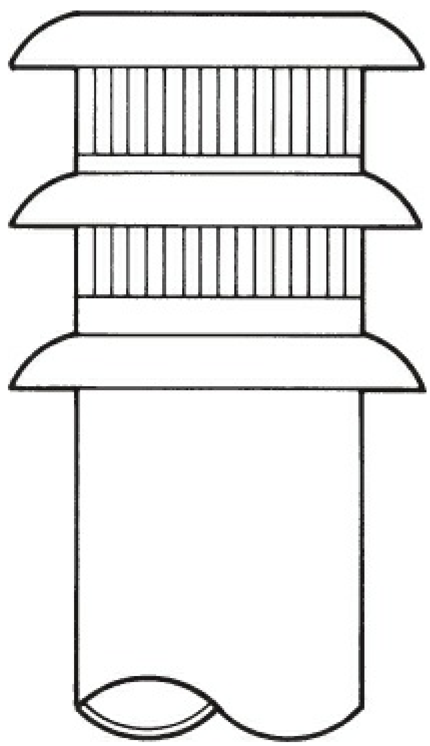


Figure 13.48 Round top termination.

Development of the Residential Fireplace

A full section of the residential fireplace is developed in four stages:

Stage I (Figure 13.49). Start with the context. Detail the plate line, floor line, wall, and roof outline. These lines establish the parameters within which the detailer can explore the framing members and place the prefabricated fireplace.

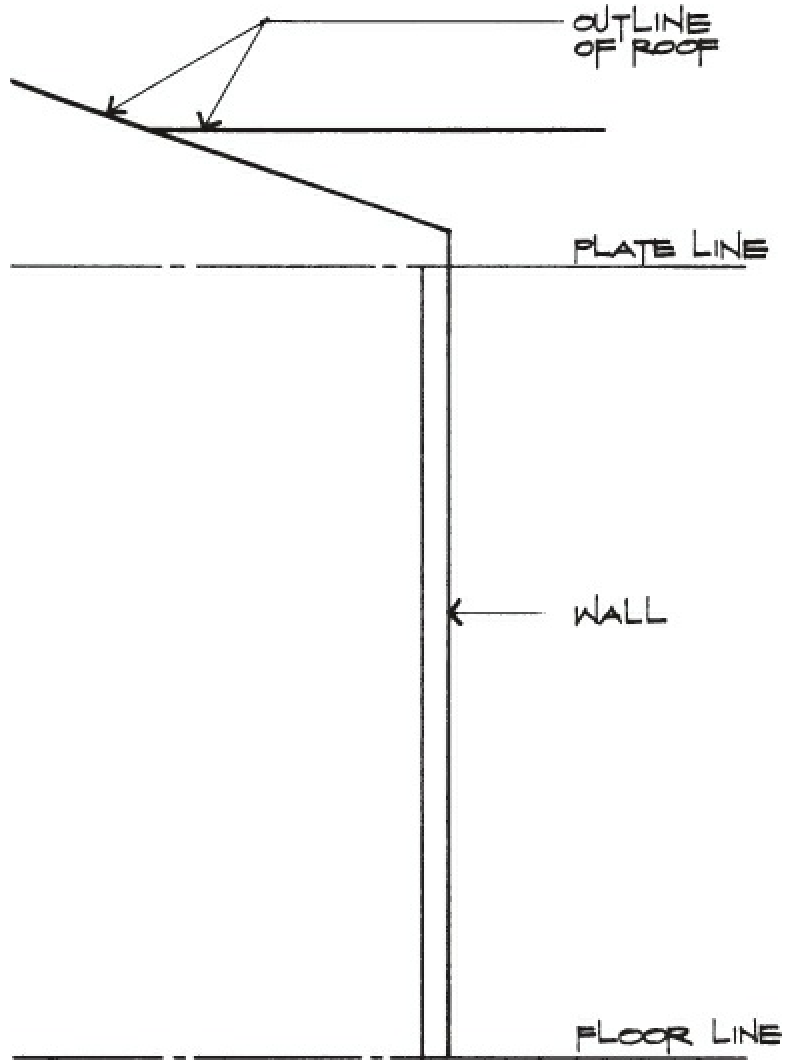


Figure 13.49 Stage I: Establishing the parameters of the fireplace location.

Stage II (Figure 13.50). The ceiling joists and rafters are sized and positioned according to the framing plan. Because this is not a masonry fireplace, the drafter need not be concerned with a foundation. (For drafting full masonry fireplaces, read the chapter on fireplaces in the companion book, *The Professional Practice of Architectural Detailing*.)

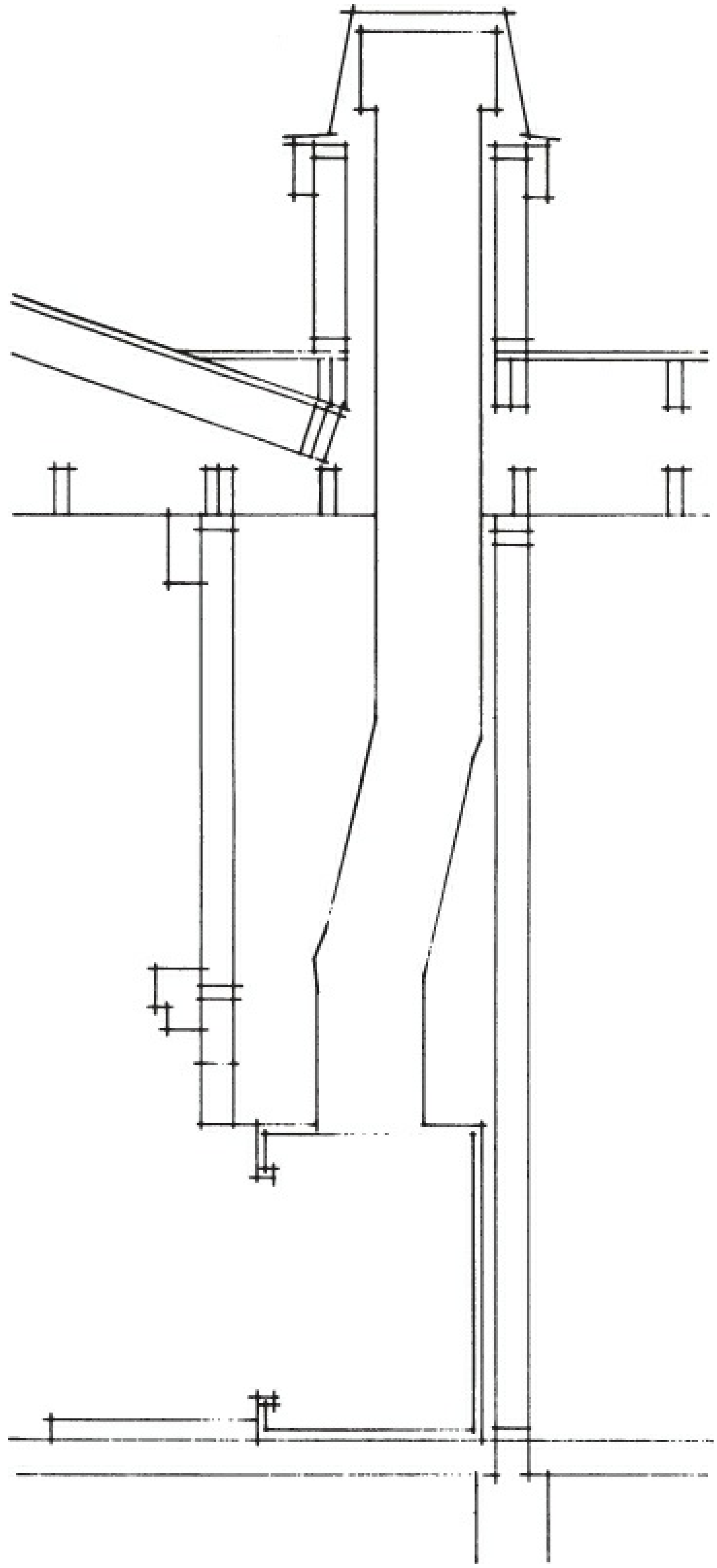


Figure 13.50 Stage II: Residential fireplace.

Next, the fireplace is positioned in this cavity, with the minimum clearances required by code. At this stage, the drafter must be conversant with code restrictions as well as the method of installation. For example, it is important to detail how the flue is to be stabilized within the cavity, what kinds of firestops are required, and where they are positioned. Manufacturers' literature includes installation instructions and standard manufactured pieces that are available to make such installation possible. The drafter should also check the project book to verify finish materials for the face of the fireplace and the hearth.

Stage III (Figure 13.51). Once the materials have been checked, material designations are included in the detail. Wood, insulation, concrete, and even the outside wall of the metal fireplace are shown. At this stage, sheet metal, such as for the cap, is drafted with a single heavy line.

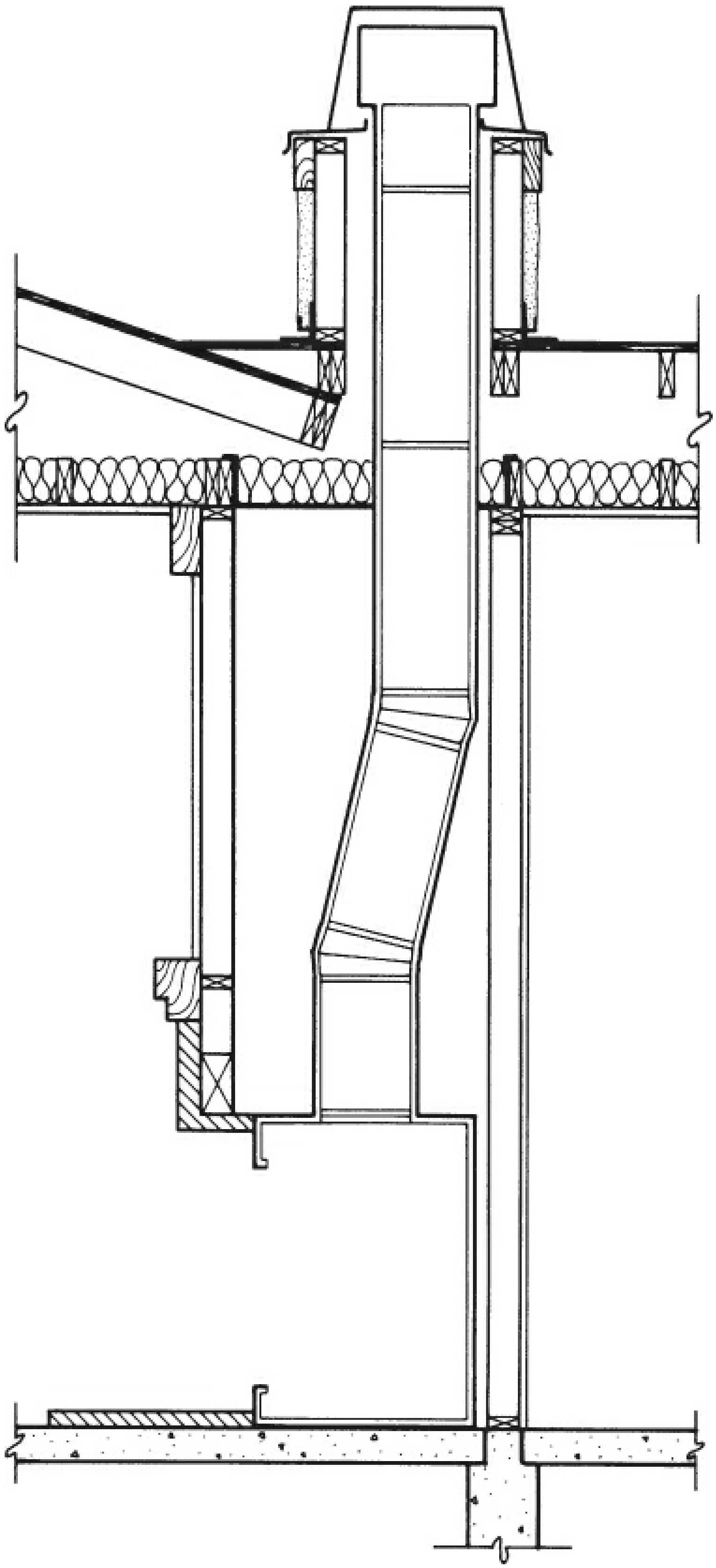


Figure 13.51 Stage III: Residential fireplace.

Stage IV (Figure 13.52). The detailer must be aware of a number of items on all details, as well as those that are unique to specific details, as is the case with a

fireplace. Unlike the footing detail, which describes a structural part of a building, the fireplace detail is one for which a context already exists. The second factor that the detailer must identify and describe accurately is the prefabricated unit itself. Thus, the final stage must be dealt with much in the same fashion as the detail was developed.

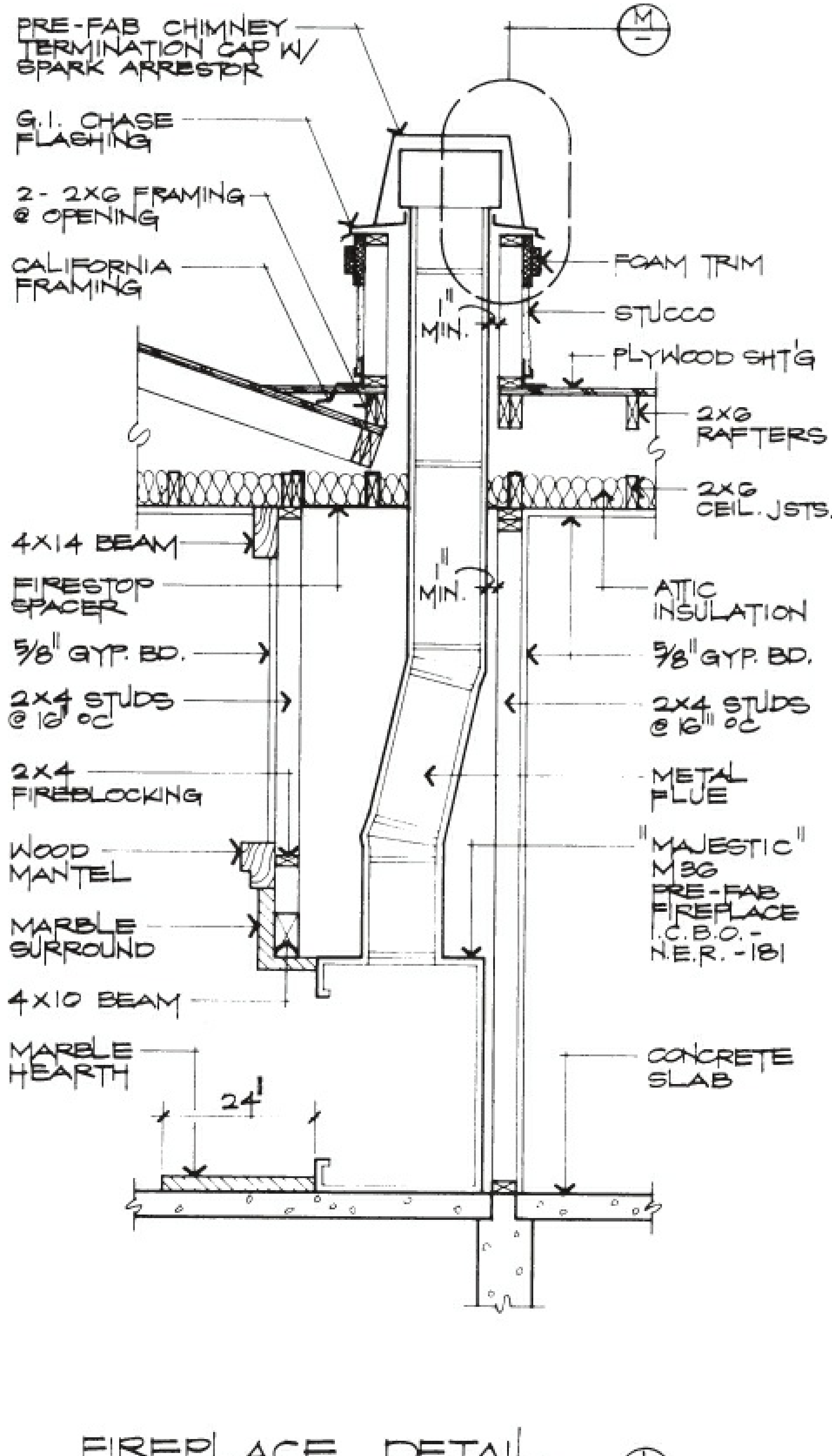


Figure 13.52 Stage IV: Half…section of fireplace.

First in the final sequence is identification of the context: the rafters, the ceiling joists, the floor, and the cell (surrounded with studs) within which the fireplace will be placed, including the housing for the chimney.

Next in this sequence is identification of the fireplace and the flue, in such a way that the outline of the fireplace is clear in relationship to the surrounding structure.

The building code and the manufacturer's installation directions will reveal certain clearances that must be maintained and dimensioned, and attachments and firestop spacers that must be identified. Merely positioning them is not sufficient.

Next, the decorative (**noncombustible**) portions that surround the opening—the chimney, the floor (**hearth**) and the wall plane of the fireplace, and the ceiling—should be described and dimensioned.

Finally, if there are portions within this drawing that should be enlarged and explored, reference bubbles or notes are included to direct the reader to these details. Although it may seem that this is referring a detail to a detail, it is really not. (See the chimney portion of Figure 13.47.) This drawing, as the title indicates, is a **half_section**—a hybrid between a building section and a full…blown detail.

Stair Design and Vertical Links. The stair design for any type of stairway will have to address the various physical and dimensional requirements while adhering to building code restrictions. The architect will need to have some basic information before designing the stairs and the accompanying stair details. The first information required is the computed height between the floor levels. Second, the designer needs the dimensional requirements for the width of the stairs, and the length of the stair run, to accommodate the number and width of the desired stair **treads**. After the floor…to…floor dimension is computed, this dimension will then become the basis for the number and height of the stair risers. An example of how this may be achieved is described mathematically as follows:

1. Floor to ceiling = 8′…0″
2. Ceiling thickness = 5⁄8″
3. Second…floor wood joist = 11¼″
4. Second…floor subfloor = ¾″

Therefore, the floor…to…floor dimension is 9′…05⁄8″ or 108.625″.

Desired riser height dimension = 6½″ to 7″

Desired tread dimensions = 10½″ (11″ for commercial)

Riser Computation Example

Assume that there are 15 risers; therefore, 108.625″ divided by 15 equals 7.28″ + risers or 7 3/8″ risers. This does not meet current building code requirements. Try 16 risers:

108.625″ divided by 16 equals 6.79″ or 6¾″ + risers, which does meet building code requirements. Most building codes require that a rise in every step be not less than 4″ nor greater than 7″.

Tread Computation Example

Prior to computing the number and size of the treads for the preceding riser example, it is recommended that the governing building code requirements for the minimum width of the tread size be verified. Most codes require the tread size to be not less than 11″ as measured horizontally between the vertical planes of the furthermost projection of the adjacent treads.

As determined by the foregoing riser computation, the stair calls for sixteen 6¾″ risers. For most stairway designs, the number of treads will be one less than the number of risers. Therefore, for the tread computation and code requirement, fifteen 11″ treads will be used in this example. To compute the dimensional length of the stairway run using fifteen 11″…wide treads, it would mathematically equate to 15 × 11″, or 165″. Therefore, the critical dimension to satisfy the number of treads in feet and inches would be 165″ divided by 12, which converts into a minimum space requirement of 13′…10″.

Stair Width

The desired or required stairway width will vary with the architect's design and the type of building that the stairway serves relative to the building code requirements. For most governing building codes, the required stairway width for commercial and public buildings must not be less than 44″. In stairways serving residential structures or having an occupant load of less than 49, the stairway must not be less than 36″ in width.

Handrails

Handrail designs and their projection into the required stairway width are governed by existing building code requirements. The allowed distance is 3½″ from each side of a stairway. A three…dimensional drawing of an acceptable handrail design is shown in Figure 13.53. The height and tops of handrails and the handrail extensions must not be less than 34″ nor more than 38″ above the nosing of the treads and stairway landings.

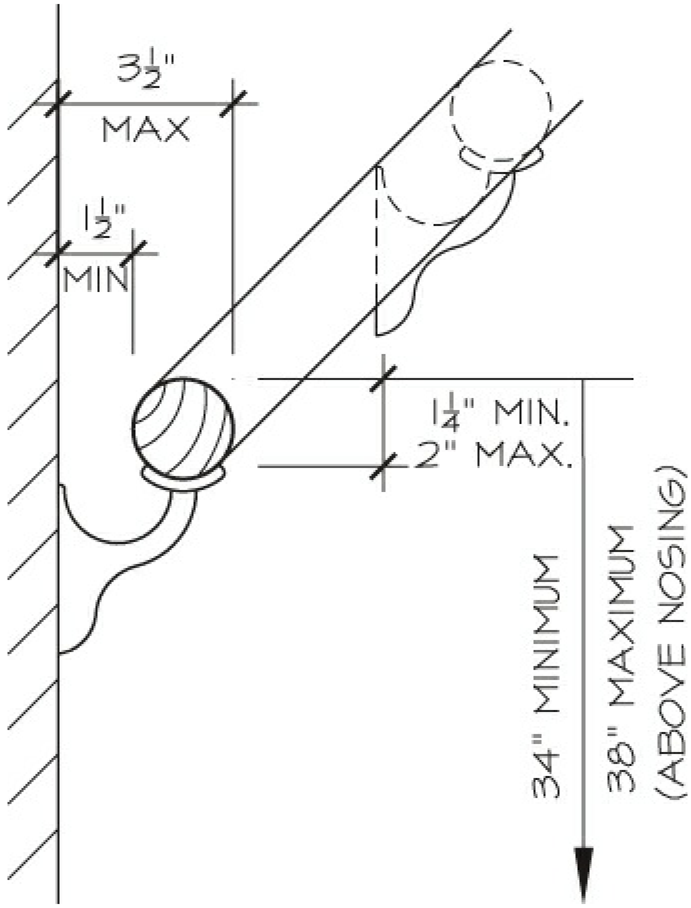


Figure 13.53 Handrail requirements.

Headroom

Another concern for a stairway designer is the minimum headroom clearance stipulated in most building codes. Generally, the headroom clearance must not be less than 6′…8″ or 6.67″ (verify with local code). This clearance is to be measured vertically from a place that is parallel and tangent to the stairway tread nosings. Figure 13.54 graphically depicts a minimum headroom clearance requirement for a stairway.

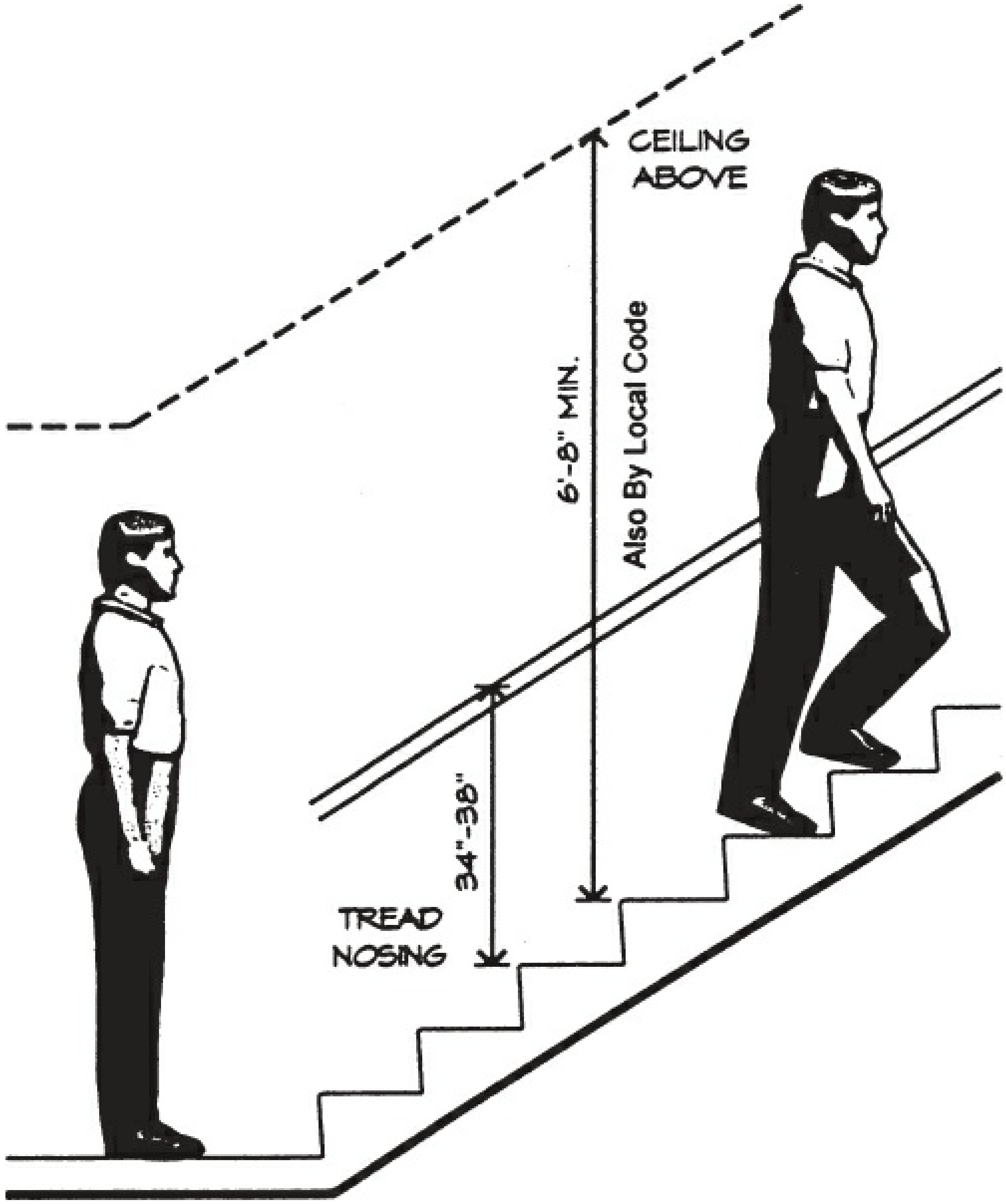


Figure 13.54 Headroom clearance.

The foregoing information and examples illustrate the basic concerns in designing stairways for a specific structure and the spaces required to meet these concerns. For further information on stairway designs and the various materials from which they may be constructed, refer to the third edition of *The Professional Practice of Architectural Detailing* (John Wiley & Sons, Inc.).

Guardrails

Guardrails are safety devices found on stairway landings, balconies, and decks where the height of those elements is 30″ or more above the adjacent grade or floor below. The structural design to stabilize the supporting vertical members is predicated on a horizontal force, measured in pounds per linear foot, and must be calculated by a structural engineer. Allowable openings in the guardrail assembly, as required by most building codes, depend on the occupancy classification and use of the structure. For residential use, the maximum clear openings must not exceed 4″. For commercial and industrial structures, the maximum clear openings must not exceed 4″ and 42″ high. An example of a guardrail assembly is shown in a three…dimensional drawing in Figure 13.55.

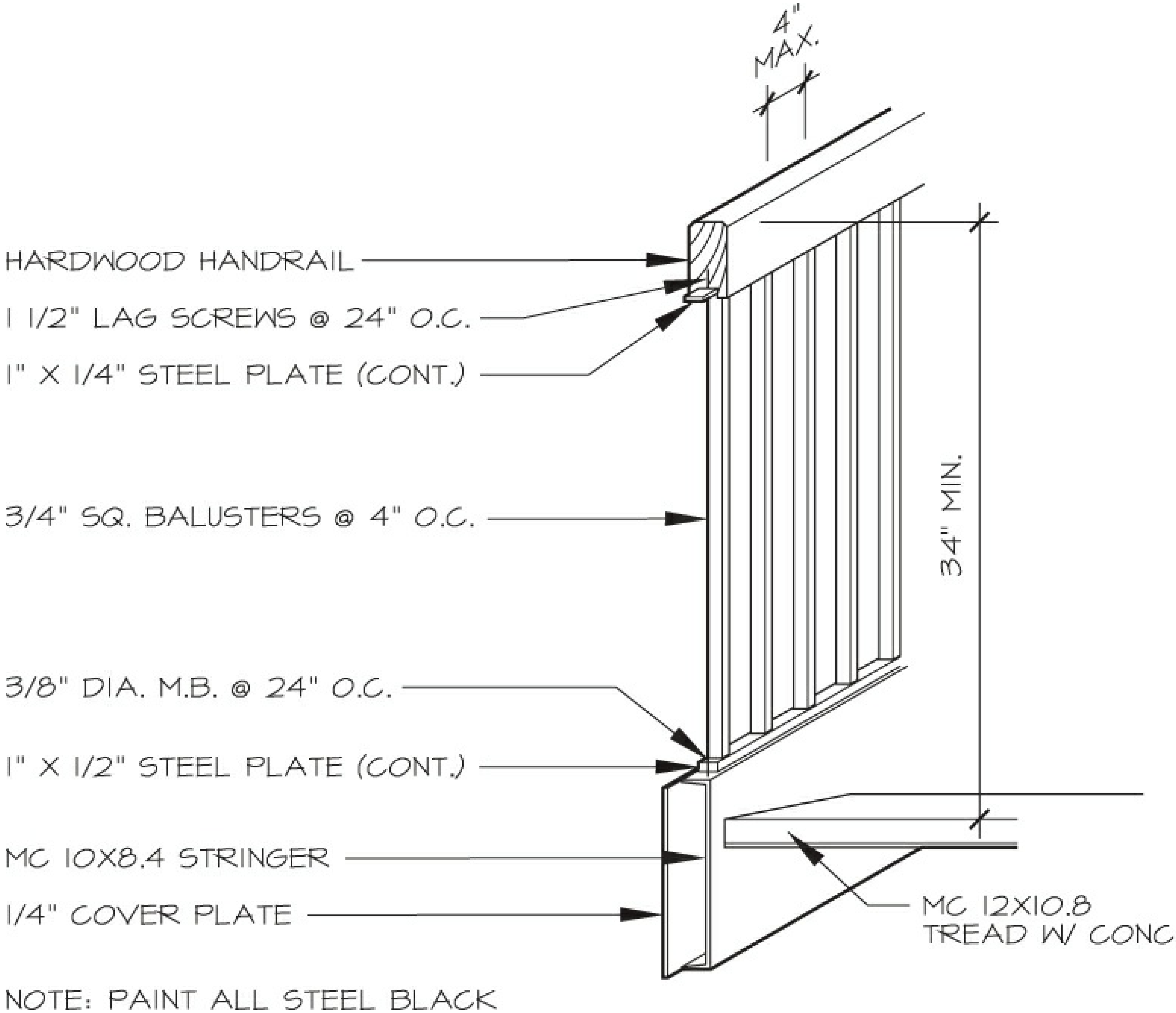


Figure 13.55 Balustrade detail.

The construction materials used for stairways include wood, steel, poured…in…place concrete, precast concrete, or a combination of any of these materials. Figures 13.56, 13.57, and 13.58 illustrate a partial floor plan for a three…story residence that incorporates a wood stairway construction at the different floor levels. The stairway designs vary from a straight run and landings to a partial radial shape.

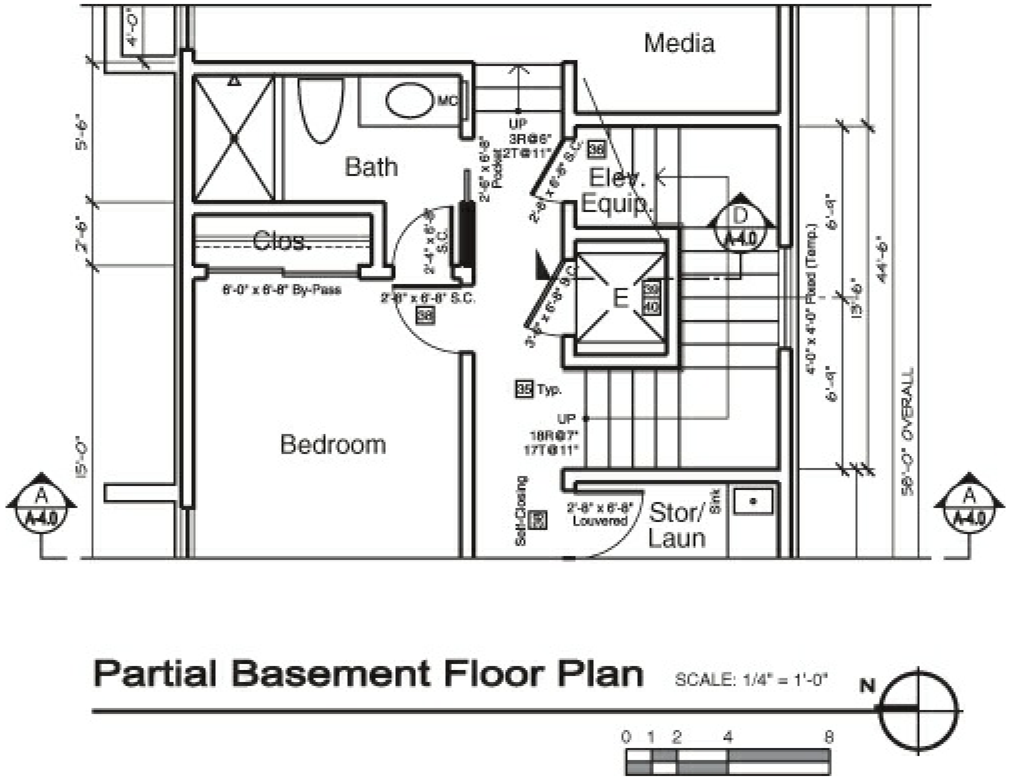


Figure 13.56 Partial basement…floor plan.

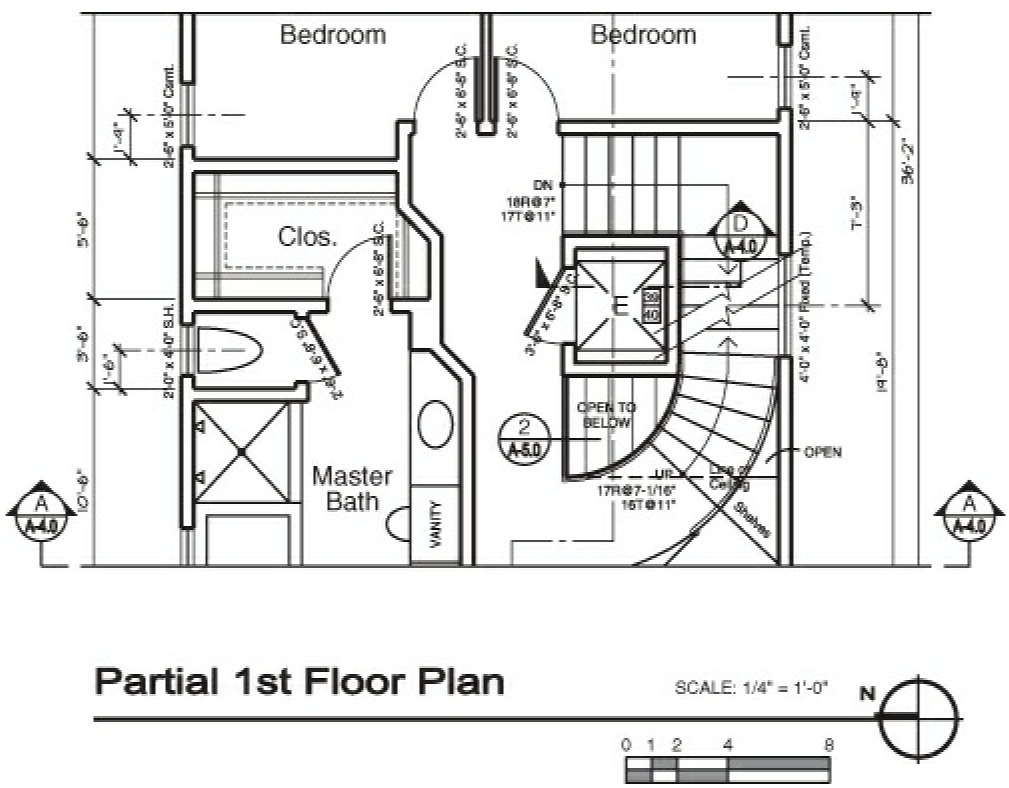


Figure 13.57 Partial first…floor plan.

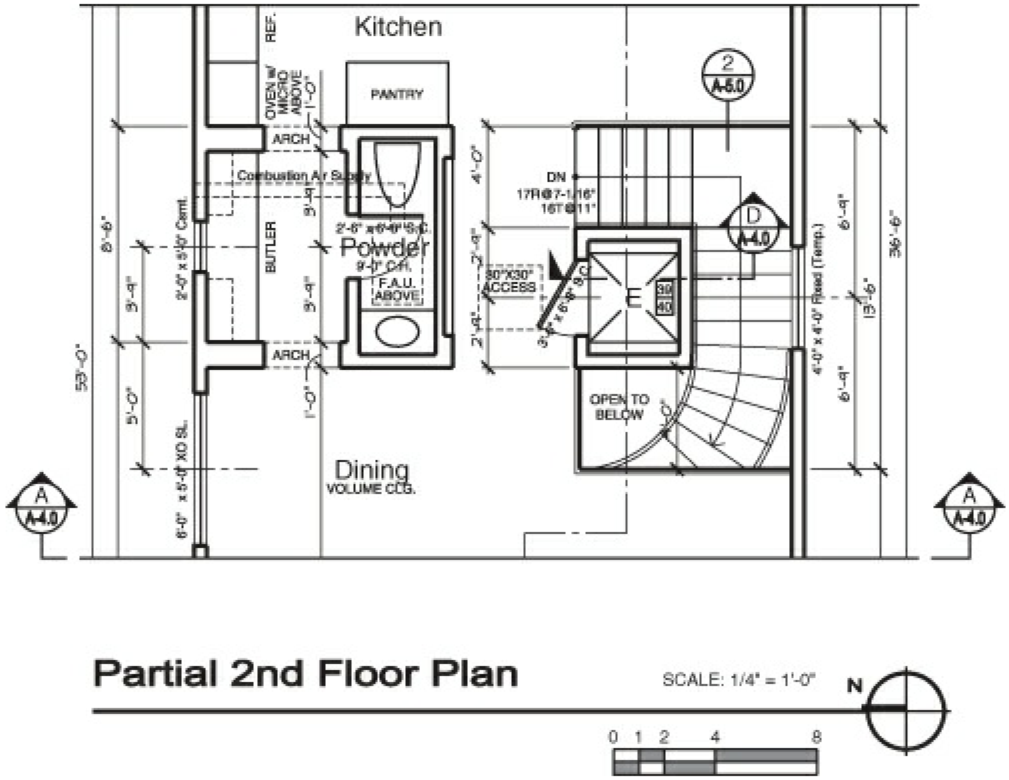


Figure 13.58 Partial second…floor plan.

Starting at the basement level, as shown in Figure 13.56, and knowing the established basement floor…to…floor dimension of 10′…6″, or 126″, the designer can calculate the number and height of the stairway risers. Starting from the basement floor…to…floor, using 7″…high risers, eighteen risers will be required. Therefore, when using 11″…wide treads, seventeen risers will be required. The length of the space required for seventeen 11″…wide treads will be 15′…6″ plus the width of the two stairway landings. The width of the landing is 42″, as is the width of the stairway. The foregoing information is what was required to physically lay out this stairway design, which surrounds an elevator shaft enclosure.

The next step in this stairway design is to provide stair details as part of the project's working drawings. As shown in Figure 13.59, a section is cut at the bottom of the stairway, showing how the stringers are anchored at the basement concrete floor. Another detail will show how the stringers occur at both landings (see Figure 13.60). The final detail, showing the method by which the stringers are attached to the floor joist, is illustrated in Figure 13.61.

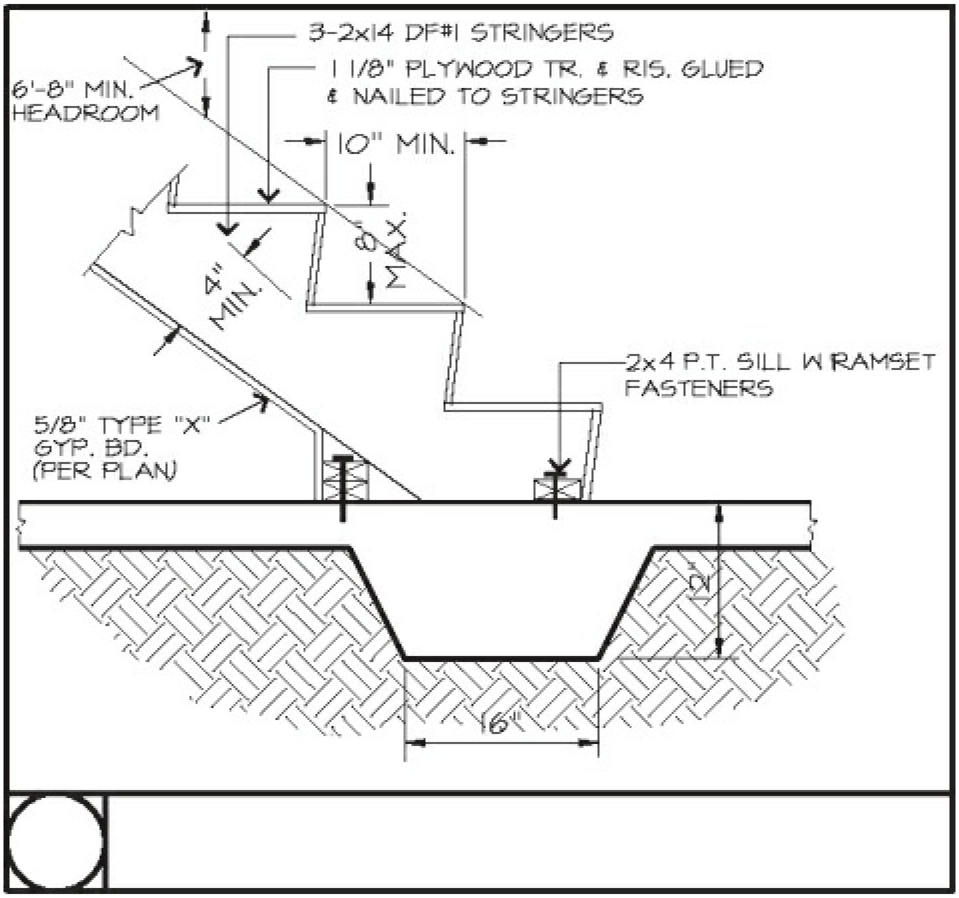


Figure 13.59 Stringers at slab.

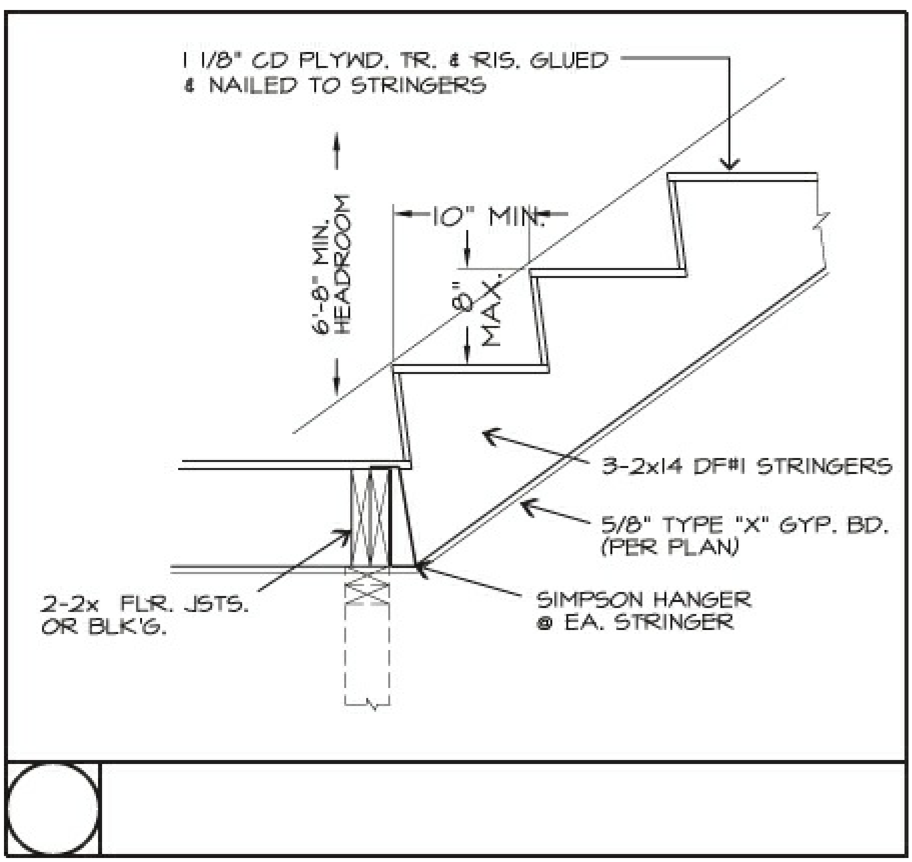


Figure 13.60 Stringers to landing.

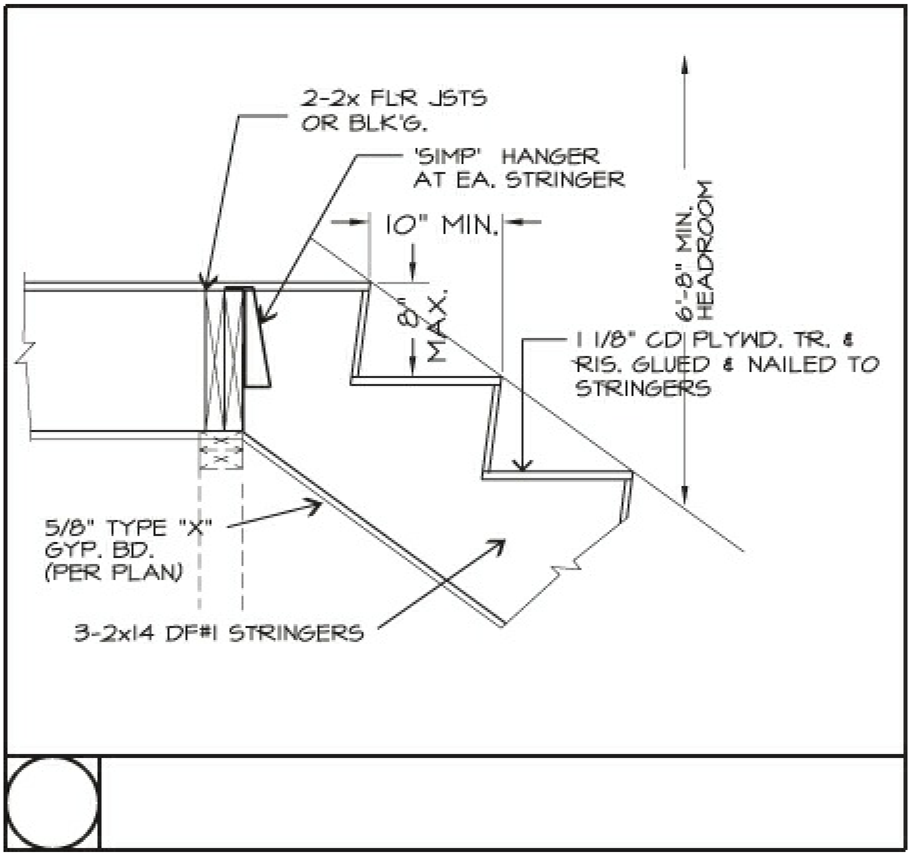
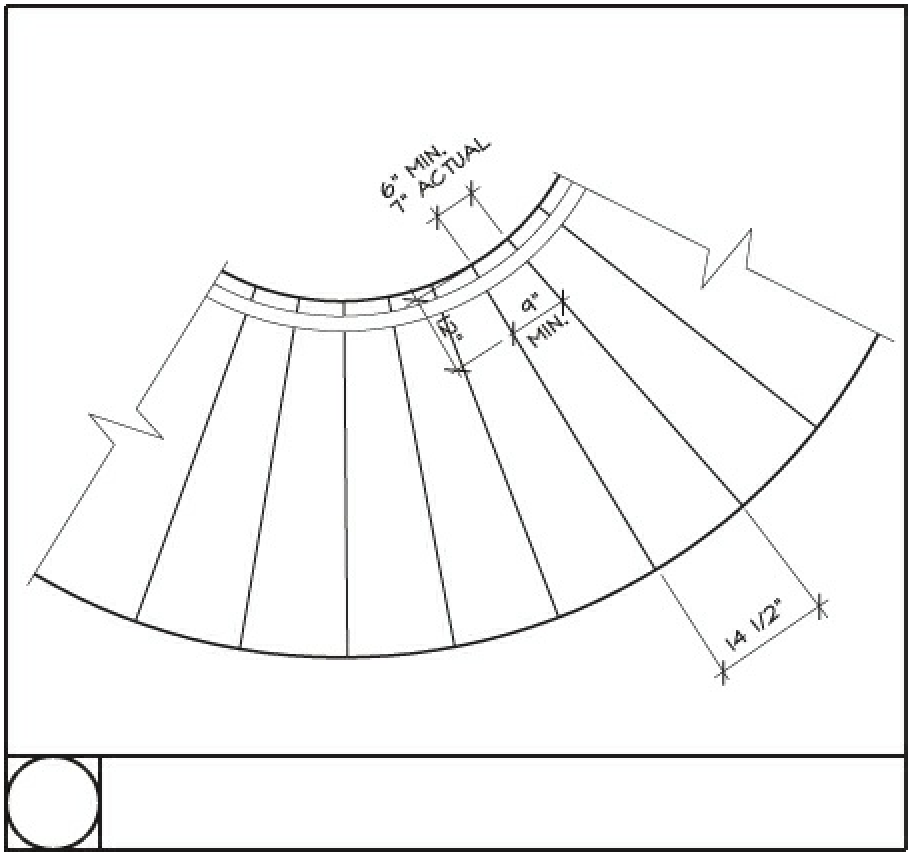
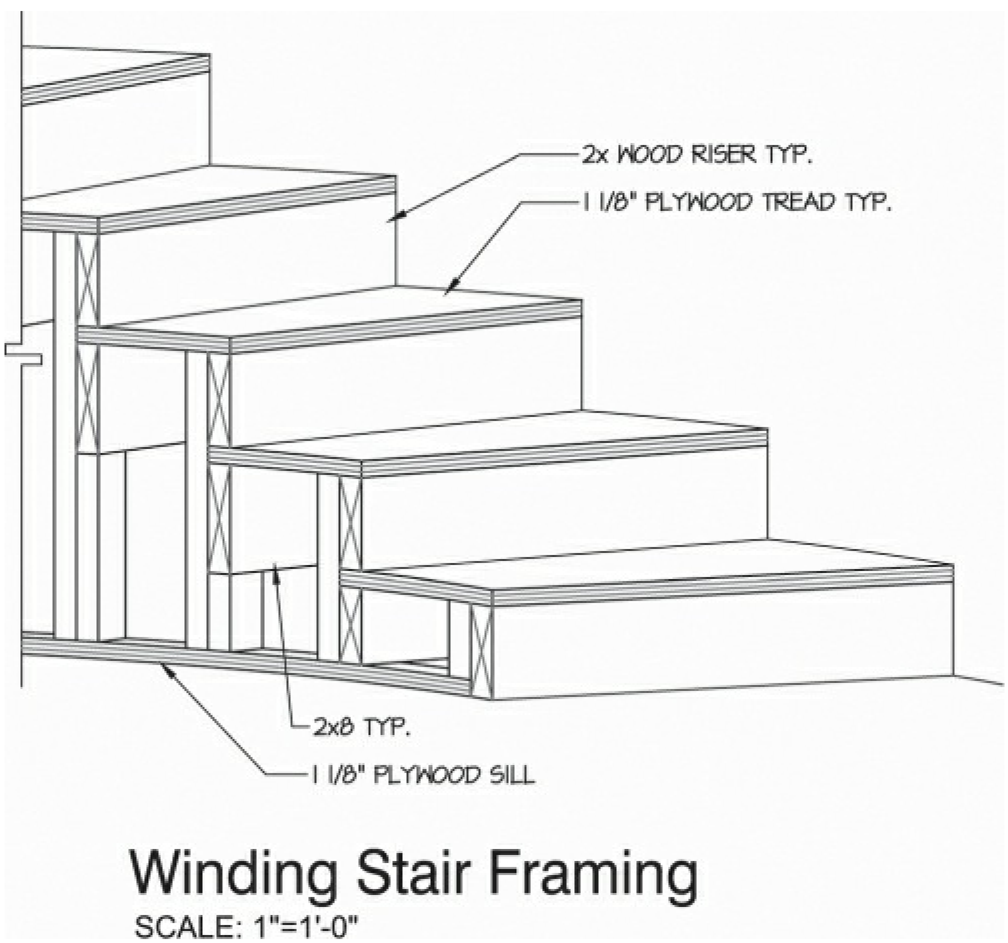


Figure 13.61 Stringers to second floor.

As shown in Figure 13.57, the stairway access at the foyer has a partial radial curve in the design. An enlarged partial stair layout of this stairway segment is illustrated in Figure 13.62. This is done to show the inside and outer dimensions of a tread as a means for construction of the stairway, while illustrating the building code requirements for the tread design. A three…dimensional detail is added to the working drawings for the purpose of clarity for this circular portion of the stairway design (see Figure 13.63).



[**Figure 13.62**] Partial stair plan.



[**Figure 13.63**] Circular stair detail.

Steel Stairway Details

Details of the steel stairway assembly used in the Madison Building are found in Chapter 6 of this book. This all‐structural‐steel building utilizes a steel‐and‐concrete stairway assembly.

Beginning at the ground‐floor level, the steel stringers, fabricated from a standard steel channel, are attached to the concrete floor with ¼″ steel plates and ½″ × 10″ anchor bolts. The typical tread design is a standard steel channel MC10 × 84 welded to the web of the channel stringer and filled with concrete. This detail assembly is illustrated in Figure 13.64.

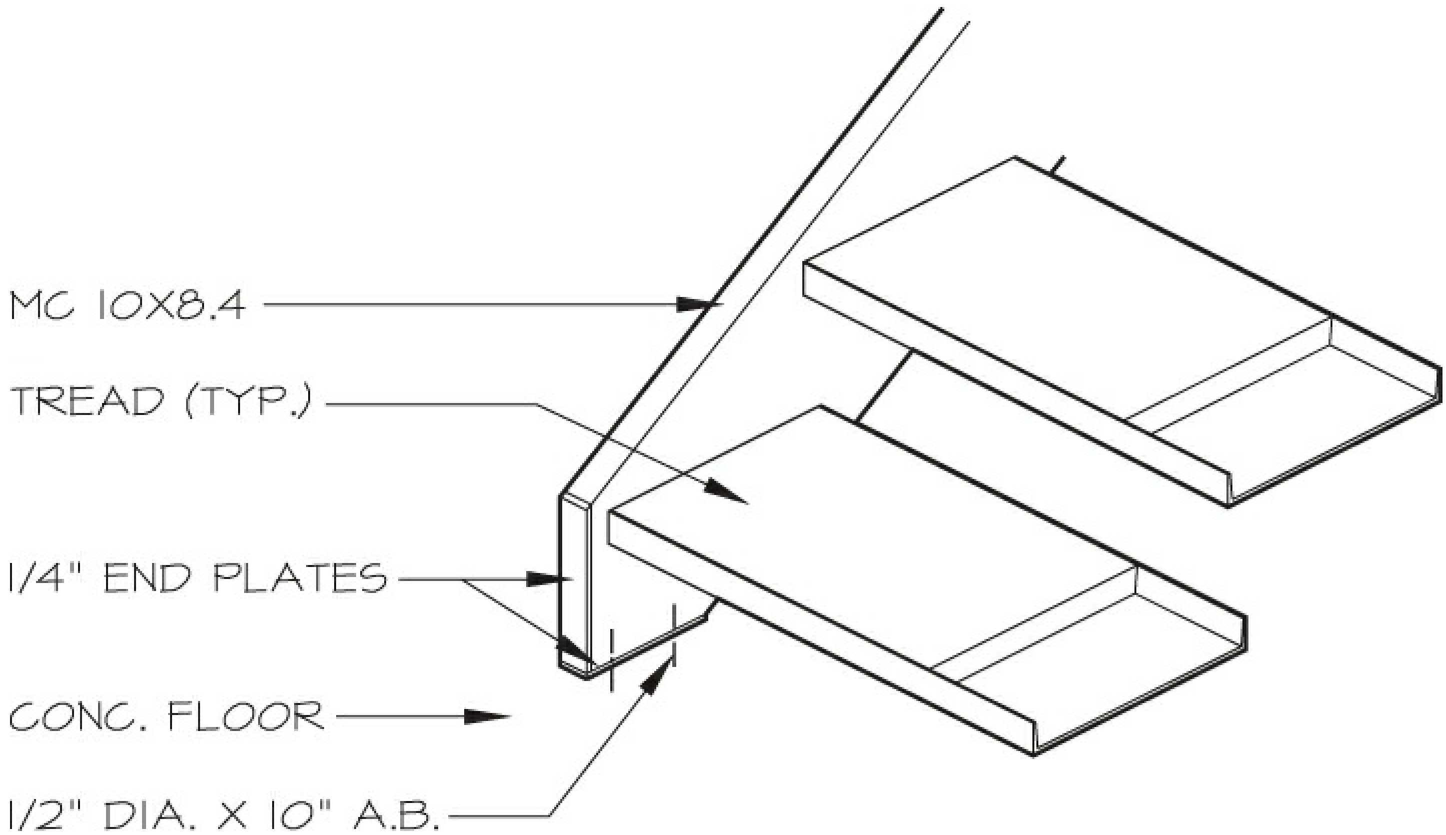


Figure 13.64 Stringer to concrete.

The next connection detail is the stringer attachment at the intermediate landings and the support of the concrete at the landings, as shown in Figure 13.65. Note that the steel channel at the landing is used to support the steel stringers and the concrete at the landings. All connections are accomplished by assigned welds. The final detail for the steel stairway assembly is shown for the various floor levels (see Figure 13.66). This detail illustrates a steel channel for the floor support and the support of the stringers. Steel angles are used for intermediate floor supports.

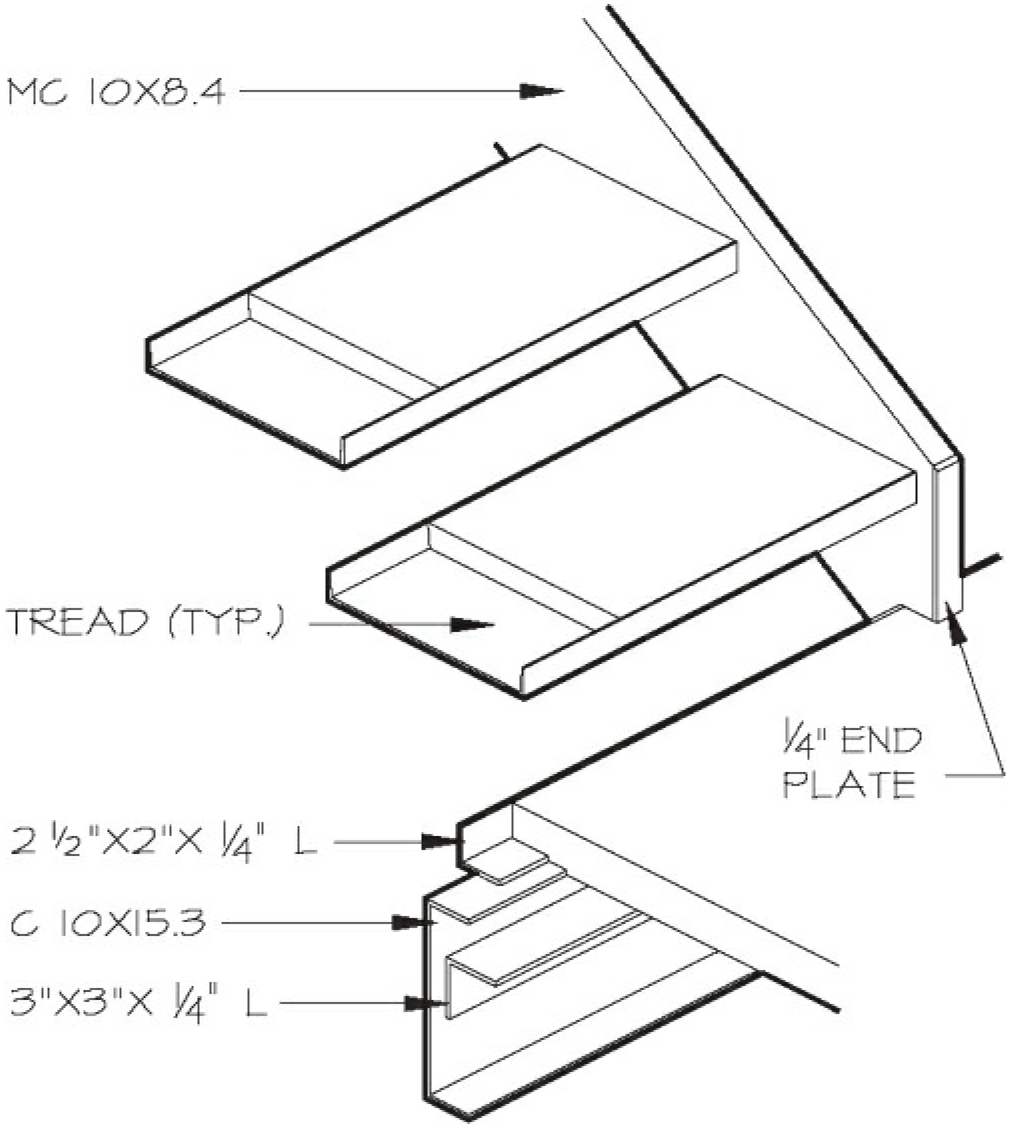


Figure 13.65 Stringer to landing.

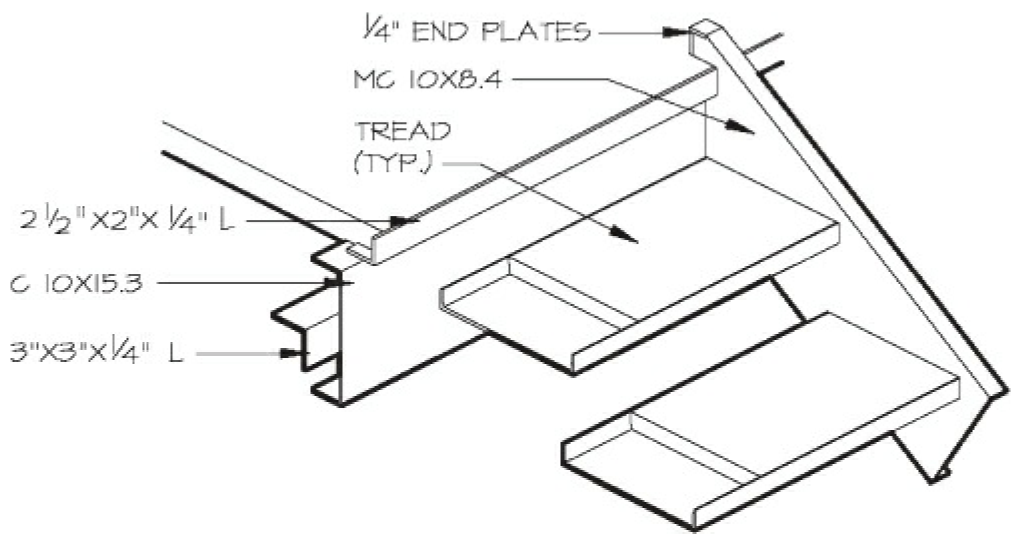


Figure 13.66 Stringer to floor.

Concrete Stairs

Concrete stairways may be constructed in two ways. First, there are various precast concrete companies that manufacture different types of concrete stairs and will deliver and install them on the building site. Second, concrete stairways may be formed during

construction of the building by incorporating the required steel reinforcing bars and then pouring the concrete in place. For many projects, a precast concrete stairway is desirable, because there is no cost of forming and subsequent form removal. When using a poured…in…place concrete stair, it is necessary to provide details, with the required steel reinforcing as part of the working drawings. A three…dimensional detail for a poured…in…place concrete stairway is depicted in Figure 13.67.

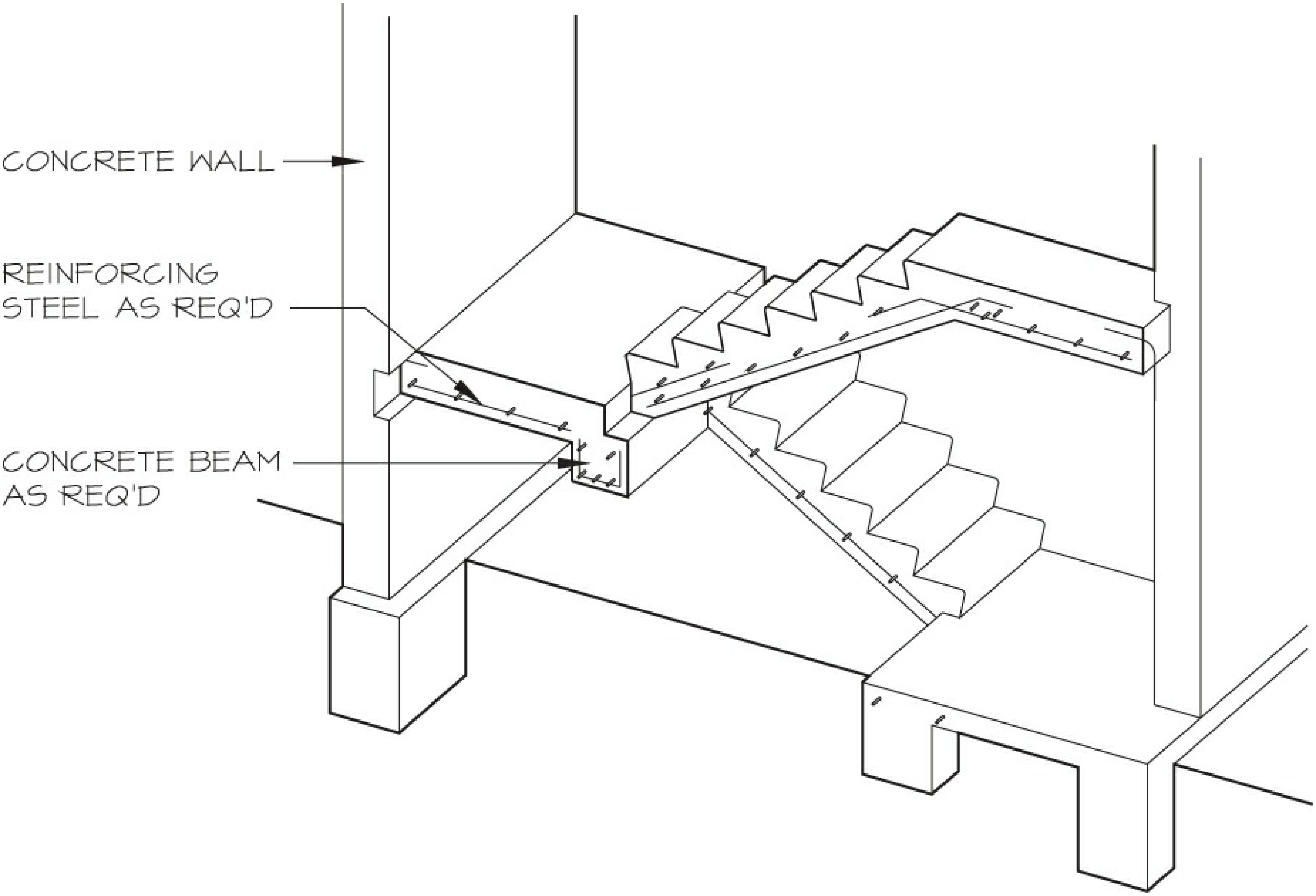


Figure 13.67 Poured…in…place concrete stairs.

Composite Stairway Assembly

Another type of stairway uses a manufactured precast concrete, one…piece, closed tread and riser assembly. These precast units can be assembled with wood or steel stringers. This composite stairway requires architectural detailing, because it is necessary to size wood stringers for their span and the weight of the precast treads and risers and to show how they are attached to the supporting beams. A three…dimensional detail illustrating a precast tread and riser unit attached to wood stringers is shown in Figure 13.68.

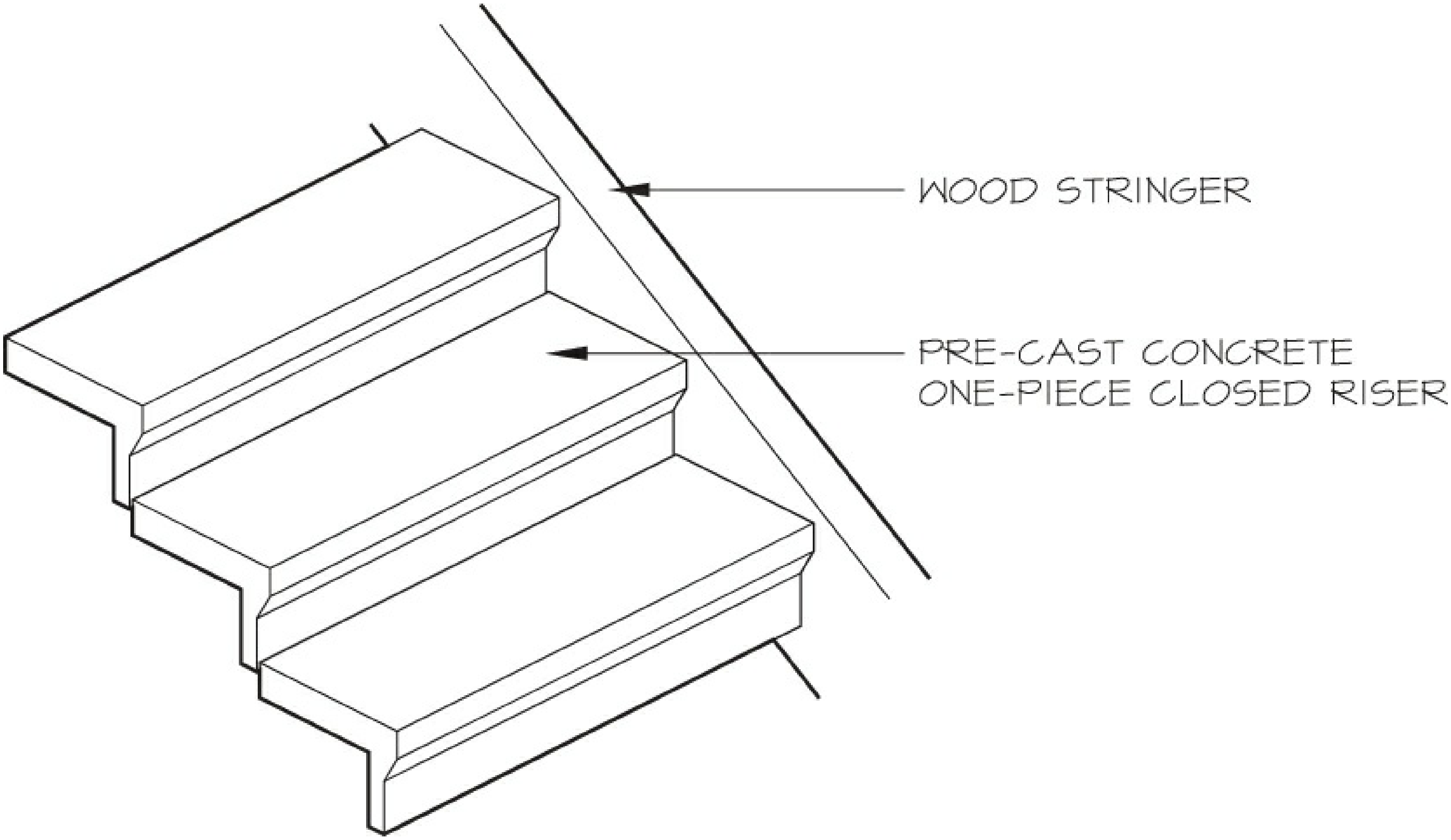


Figure 13.68 One‐piece closed riser.

Mechanical Vertical Links. The drawings for elevators of all types, and various lifting devices such as wheelchair lifts, chair lifts, and others, must include the detailing necessary to satisfy the installation requirements. An example of a residential‐type electric elevator is shown in Figure 13.69. The planned area for the wall framing and the openings that surround the electric elevator car must adhere to all the clearances required by the elevator manufacturer. The planning must also include the required space designated by the manufacturer for the machine room equipment. This room is located adjacent to and under the stairway run. A three‐dimensional drawing of the framed opening is shown in Figure 13.69. This particular elevator has a lift capacity of approximately 750 pounds.

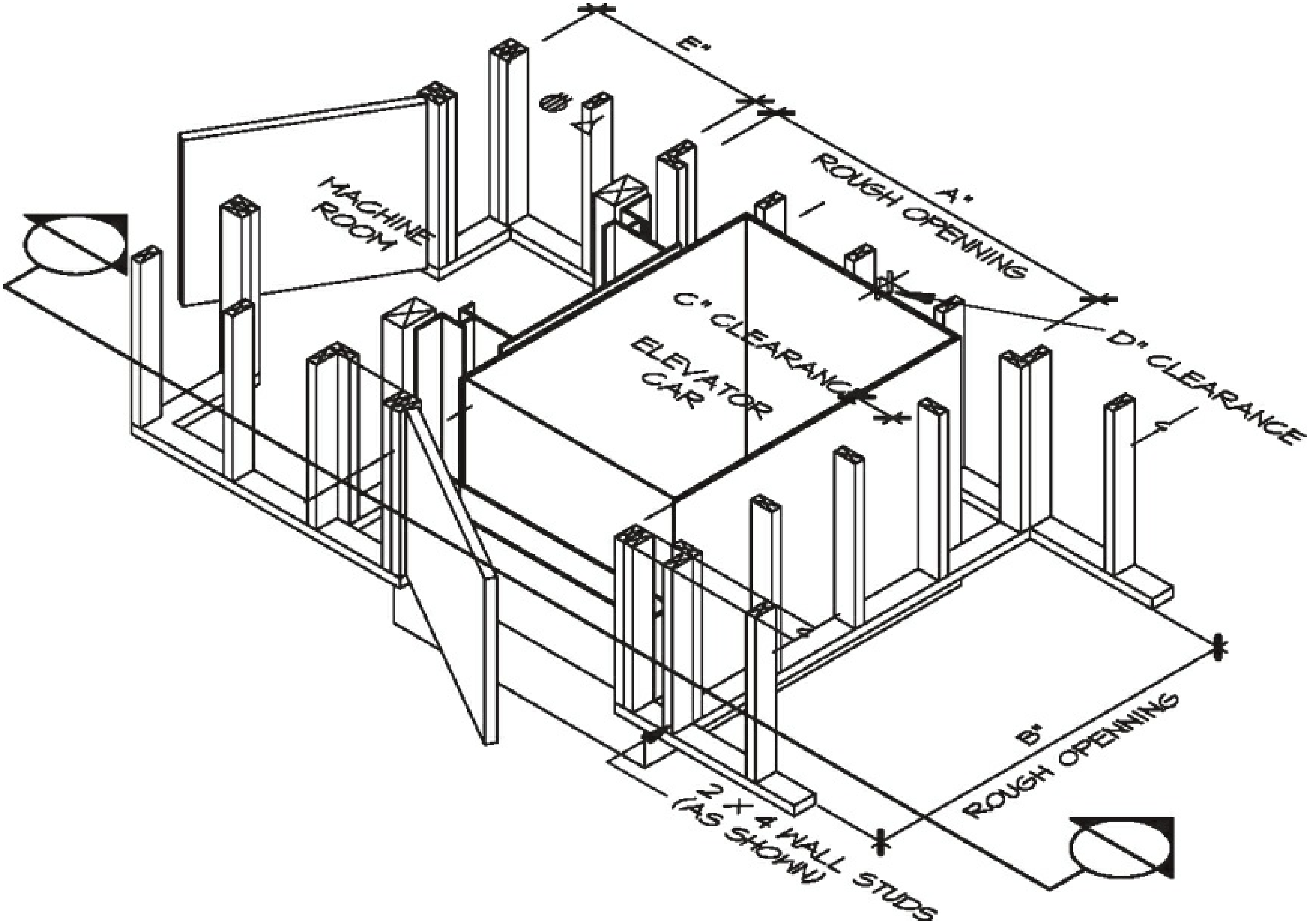


Figure 13.69 Framed elevator opening.

A more detailed example of a manufacturer's requirements is shown in the plan view illustrated in Figure 13.70. This drawing, furnished by a specific elevator manufacturer, shows the information an architect or designer will need to integrate into the working drawings. Note that the shaft dimension requirements, the clearances for this specific elevator, and the electrical supply must be shown in the working drawings. A section through the elevator shaft and machine room is shown in Figure 13.71. This drawing depicts the length of the vertical travel, the electrical supply location, and the required 8″…deep pit depression that is required for cab clearance. The area and dimensions for the pit area must be shown accurately on the foundation plan of the working drawings.

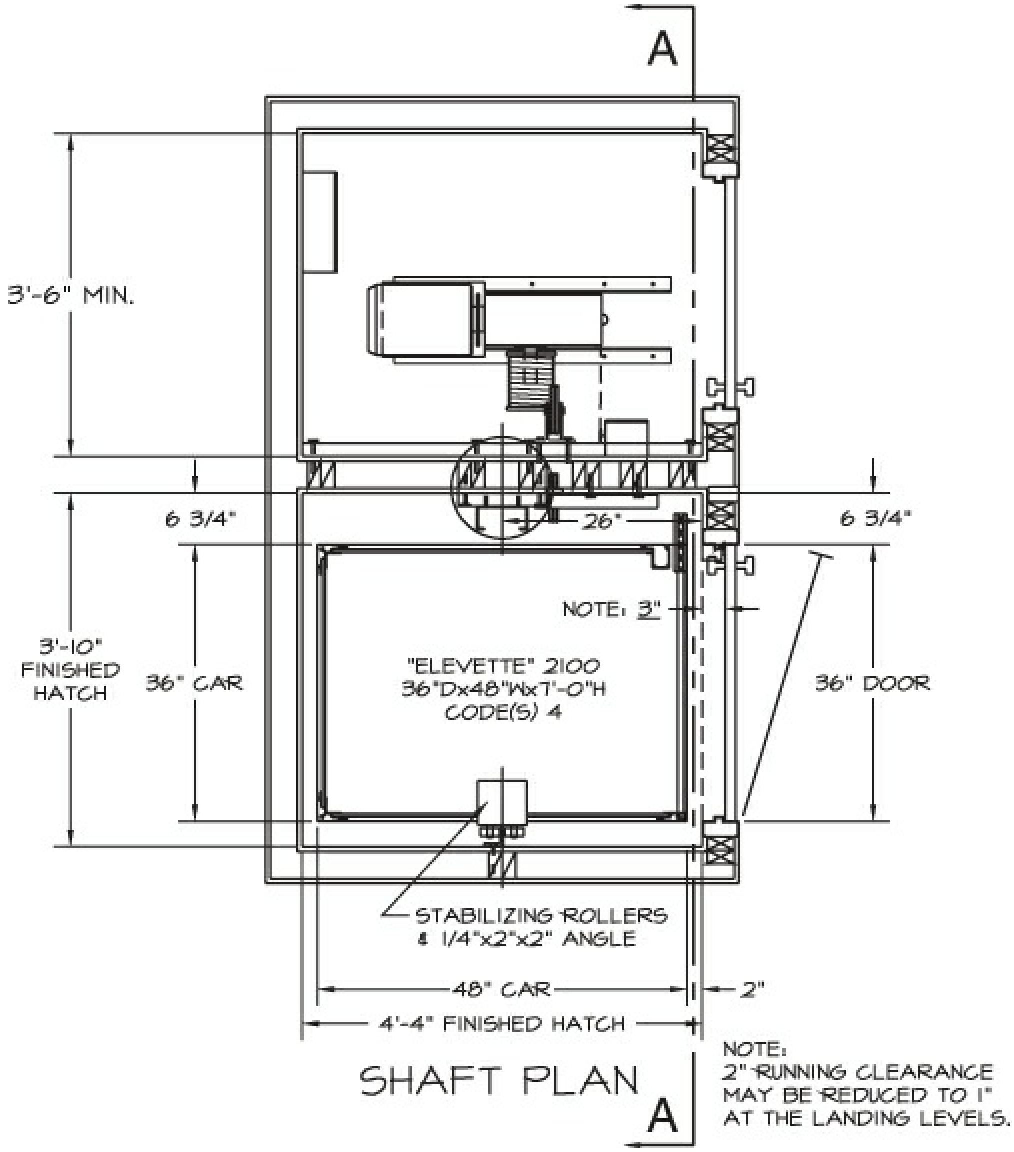


Figure 13.70 Shaft plan.

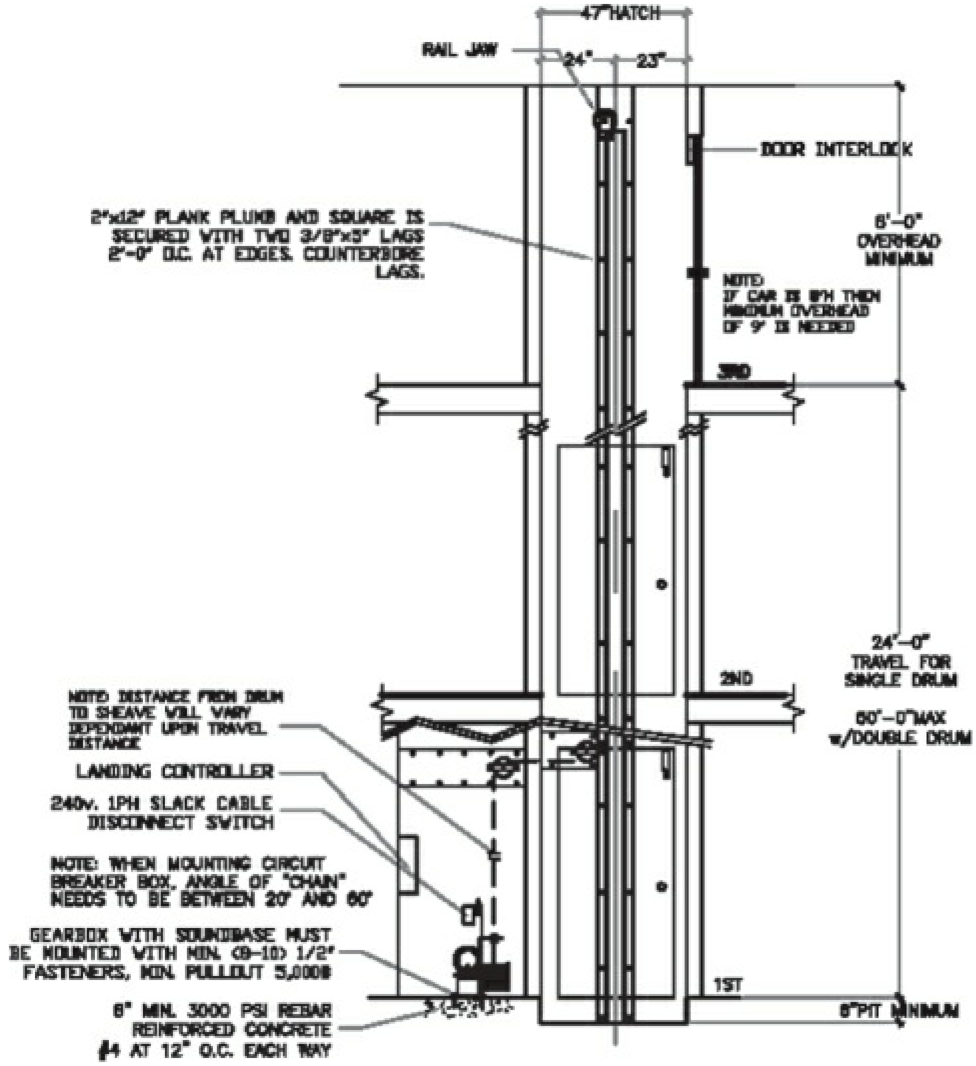


Figure 13.71 Section A…A.

To assist in planning access to the electric elevator, use the various car configurations available from the manufacturers. Examples of car configurations are illustrated in Figure 13.72. A photograph of a finished electric elevator installation is shown in Figure 13.73.

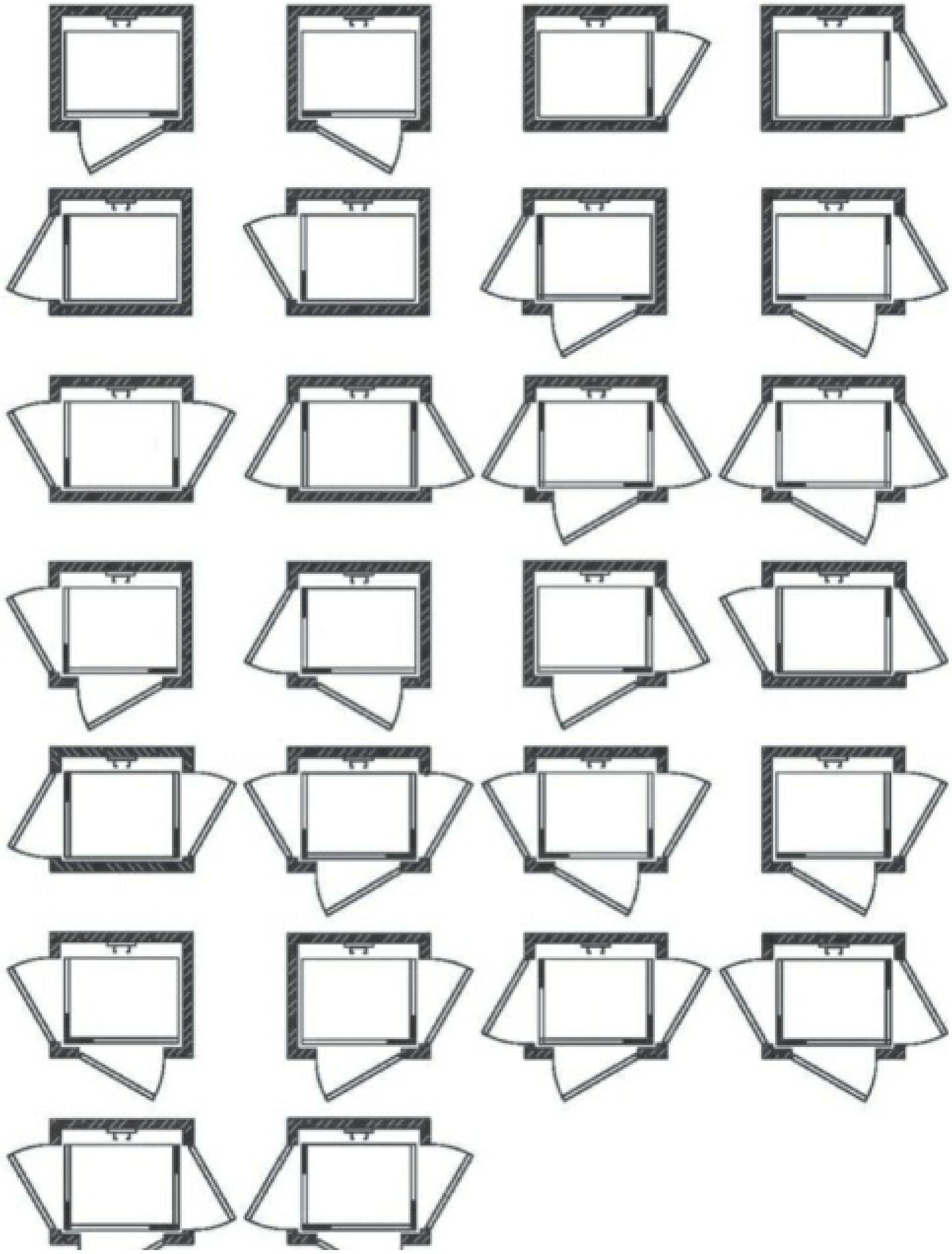


Figure 13.72 Car configurations.

Figure 13.73 Elevette.

(Courtesy Inclinator Co. of America.)

Another manufactured device used in the development of a vertical link is a stair lift. This unit is ideal for persons with walking disabilities or other physical limitations. Figure 13.74 depicts a plan view of the stair lift positions and the dimensional aspects of the unit as it projects into the stairway run. A photograph of a stair lift installation is shown in Figure 13.75.

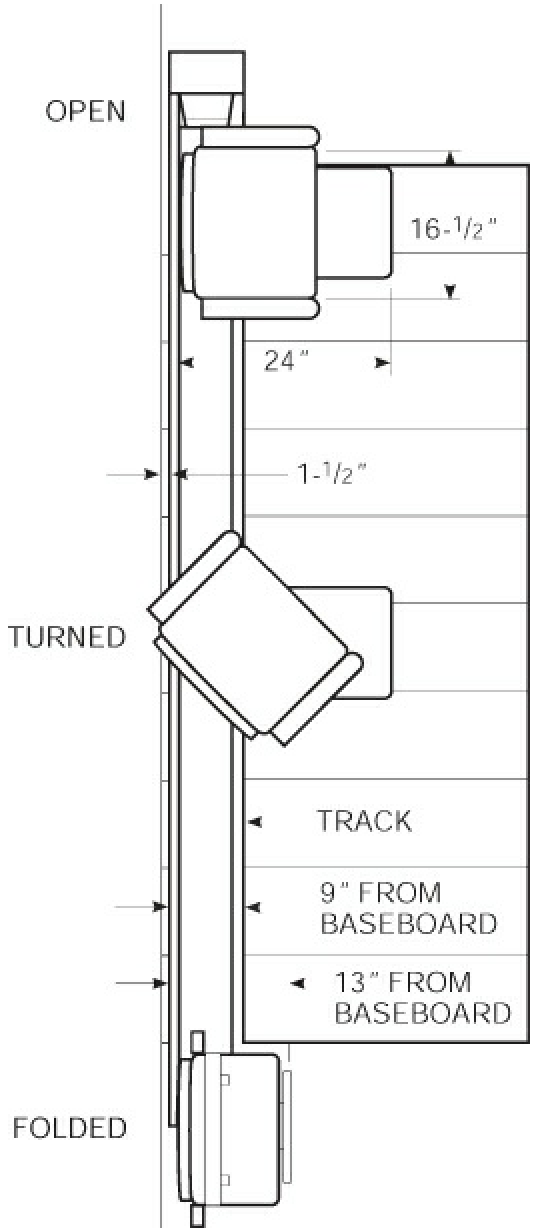


Figure 13.74 Stair lift diagram.

Figure 13.75 Stair lift.

(Courtesy Inclinator Co. of America.)

For persons who rely on the use of a wheelchair for vertical access, the use of a vertical lift is desirable. As in addressing the dimensional requirements of an elevator, the architect or designer will need to provide the dimensions, clearances, and electrical supply information as stipulated by the manufacturer's specifications. An example of a platform plan, with its requirements for a vertical lift and the vertical travel dimensions, is depicted in Figures 13.76 and 13.77. A photograph of a finished vertical lift installation is illustrated in Figure 13.78. This vertical lift unit is constructed of fiberglass that is rust…free and has a nonskid surface. Such units are available in various colors. Their maximum load capacity is 750 pounds.

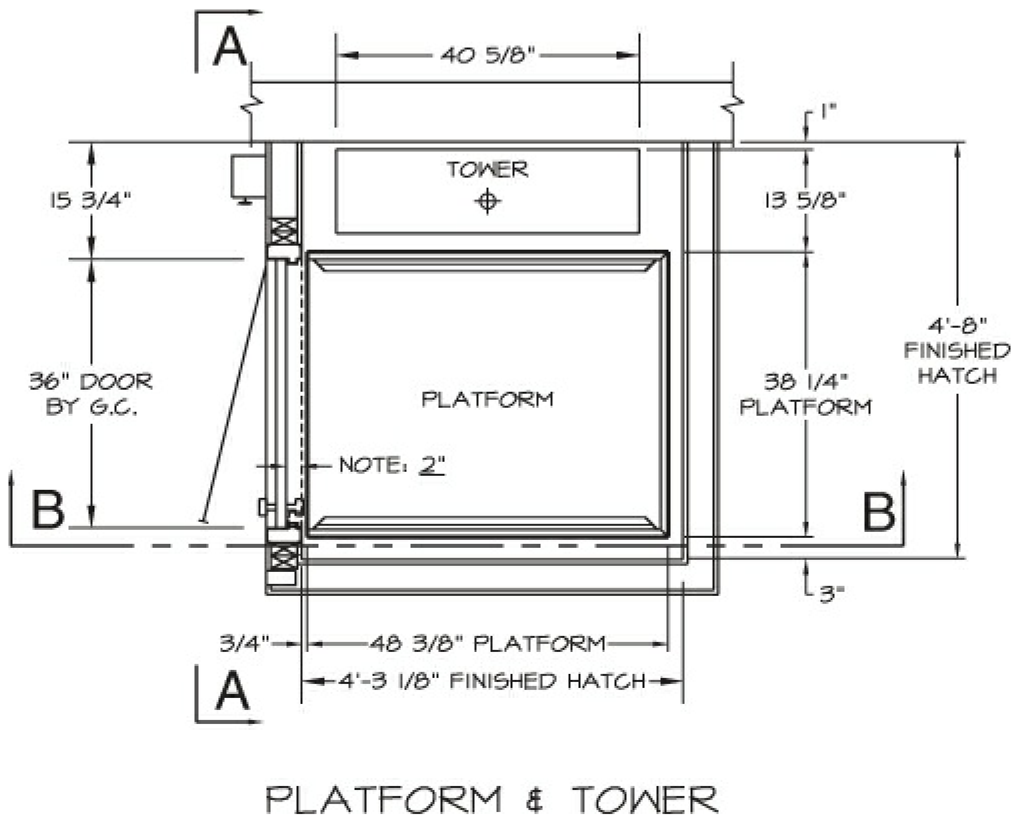


Figure 13.76 Vertical lift diagram.

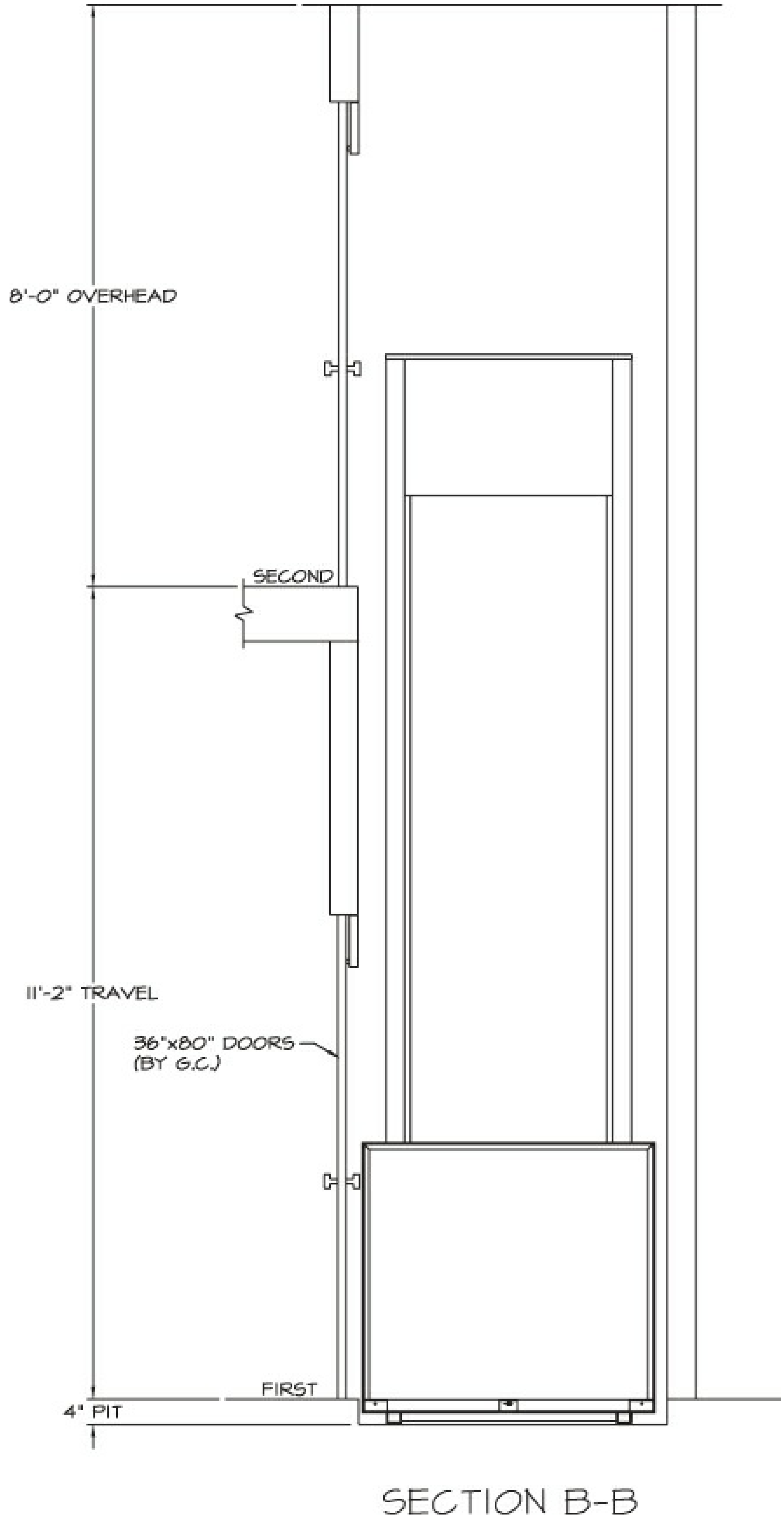


Figure 13.77 Section B…B.

Figure 13.78 Spectralift.

(Courtesy Inclinator Co. of America.)

A vertical linking unit that is convenient for lifting groceries and other heavy items from one level to another is a home waiter, frequently referred to as a **dumbwaiter**. These units vary in shaft size and maximum load capacity. The space planning and layout requirements for dimensions and clearances will be delineated in the working drawings, as described for elevators and other lifting devices. A shaft plan illustrating dimensions and clearances for a two‐landing home waiter installation is depicted in Figure 13.79. This particular unit is limited to a 75‐pound lifting capacity. Figure 13.80 shows a section of this home waiter unit illustrating the vertical travel dimensions, clearances, machine equipment room location, and the desired counter height. The vertical link units described here are but a few examples of lifting units that are found primarily in residential projects.

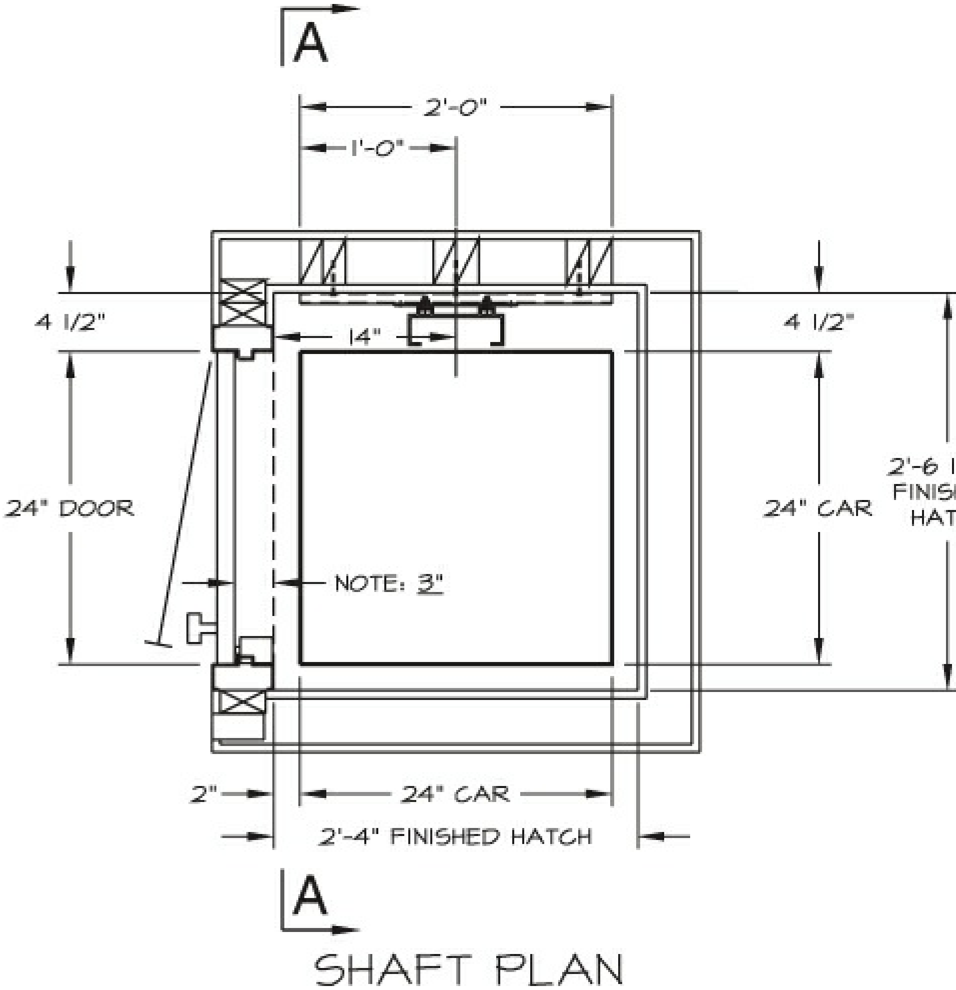


Figure 13.79 Shaft plan.

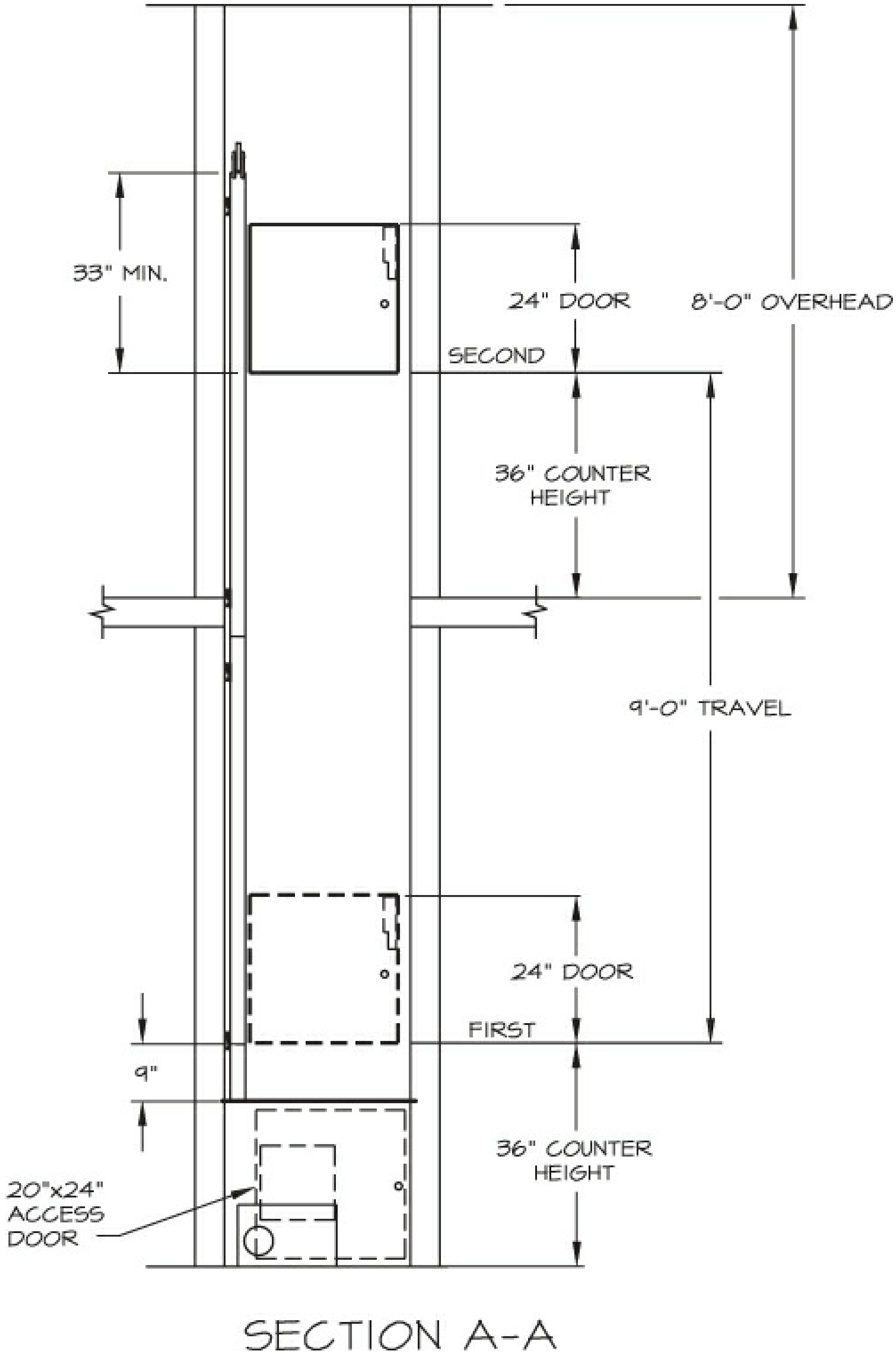


Figure 13.80 Section A…A.

Detailing in CAD. Detailing during the transition from programs such as AutoCAD or the newer building information modeling (BIM), which use the newer programs, does not mean you throw away the details you have on file to be used as a template for your new buildings. You set up a sheet per your office standards and import finished details.

Detailing on construction documents is usually done in 2…D. This is true of computer… generated details. Therefore, if you have a CAD file of details, you can easily transfer them to the newest program during the transition from the older program to the new. The details are merely scanned into the new system. Many large offices have a system whereby the needed detail is somewhat outlined and easily changed along with note that

are prewritten and selected from a large database by the head draftsman, foreman, or manager and sent to the subordinates. Although we often talk about stock details, in practice we need to customize each detail to the special task to be performed in the current project and structure. Listed here are a few of the factors that must be addressed on every detail:

- Reaction to the specific soil condition
- Foundation and structure protection from moisture and frost
- Waterproofing elements in the structure such as windows, doors, and roofing
- Checking structural recommendations for seismic activity
- Local building requirements (and good judgment) for minimums and maximums
- Clarity for construction execution

Miscellaneous Wall Sections. Depending on the governing building code requirements and the tenant's use of the operating space, there may be various wall construction requirements. In the case where a non…load…bearing, one…hour fire…rated corridor is designed to include some glazing on the corridor walls, it will be necessary to satisfy a building code requirement that calls for a ¼″…thick (minimum) wire glass secured in steel frames. A detail for this condition is illustrated in Figure 13.81.

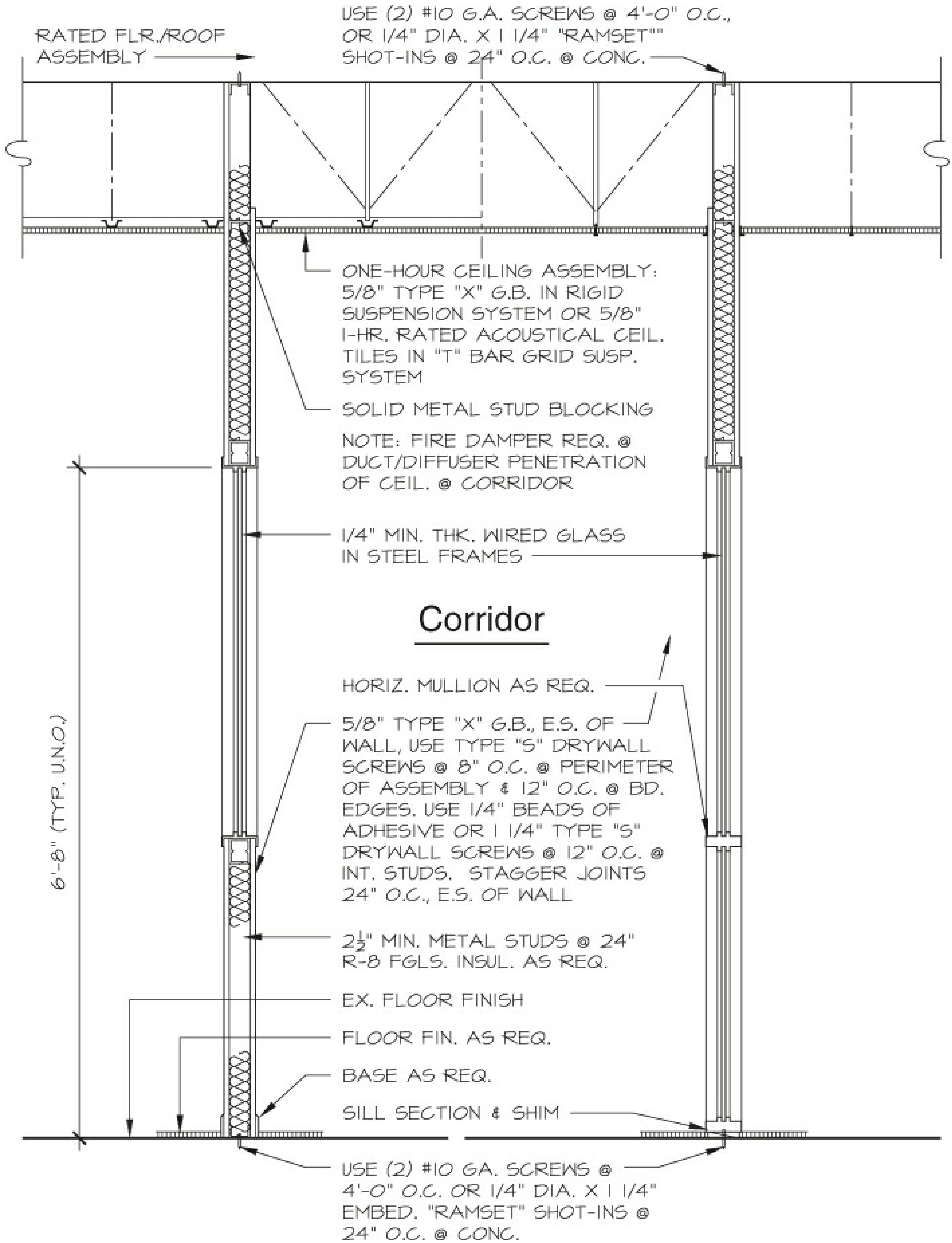


Figure 13.81 Glazed corridor wall (non‐load‐bearing).

The internal walls between the “living” spaces for tenants may require that the walls be constructed to solve two conditions: one is to satisfy a one‐hour fire‐separation requirement, and the other is to provide a means of reducing or eliminating sound

transmission between the tenant spaces. Figure 13.82 depicts the recommended non‐load‐bearing wall construction between living spaces to satisfy the fire and sound considerations.

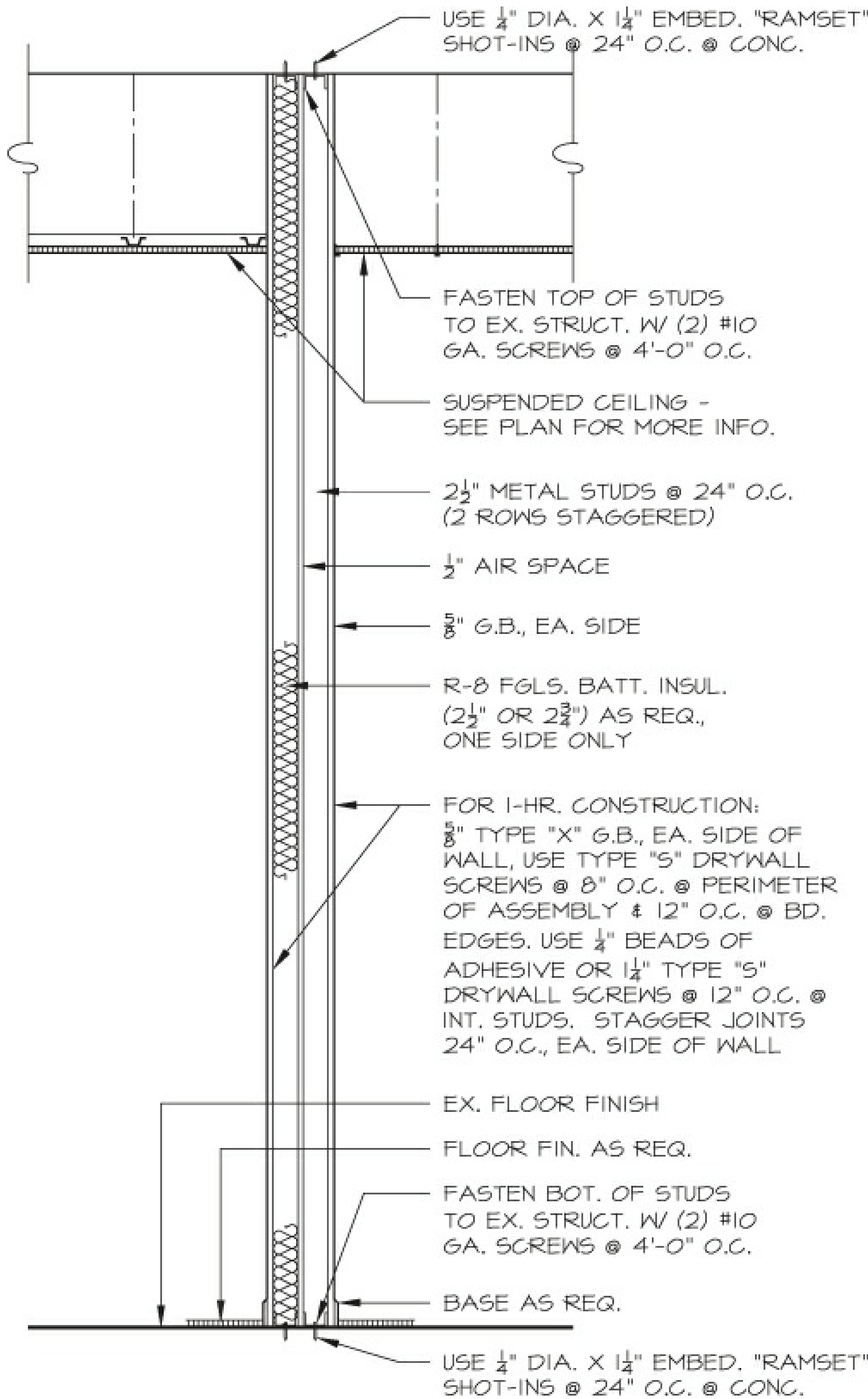


Figure 13.82 Fire and sound wall (non‐load‐bearing).

Interior door designs will vary according to the desires of the tenant and the space plan designer. An example of an interior door design detail that includes a fixed matching panel above a door is shown in Figure 13.83. This detail is designed for a non‐load‐bearing wall and door condition.

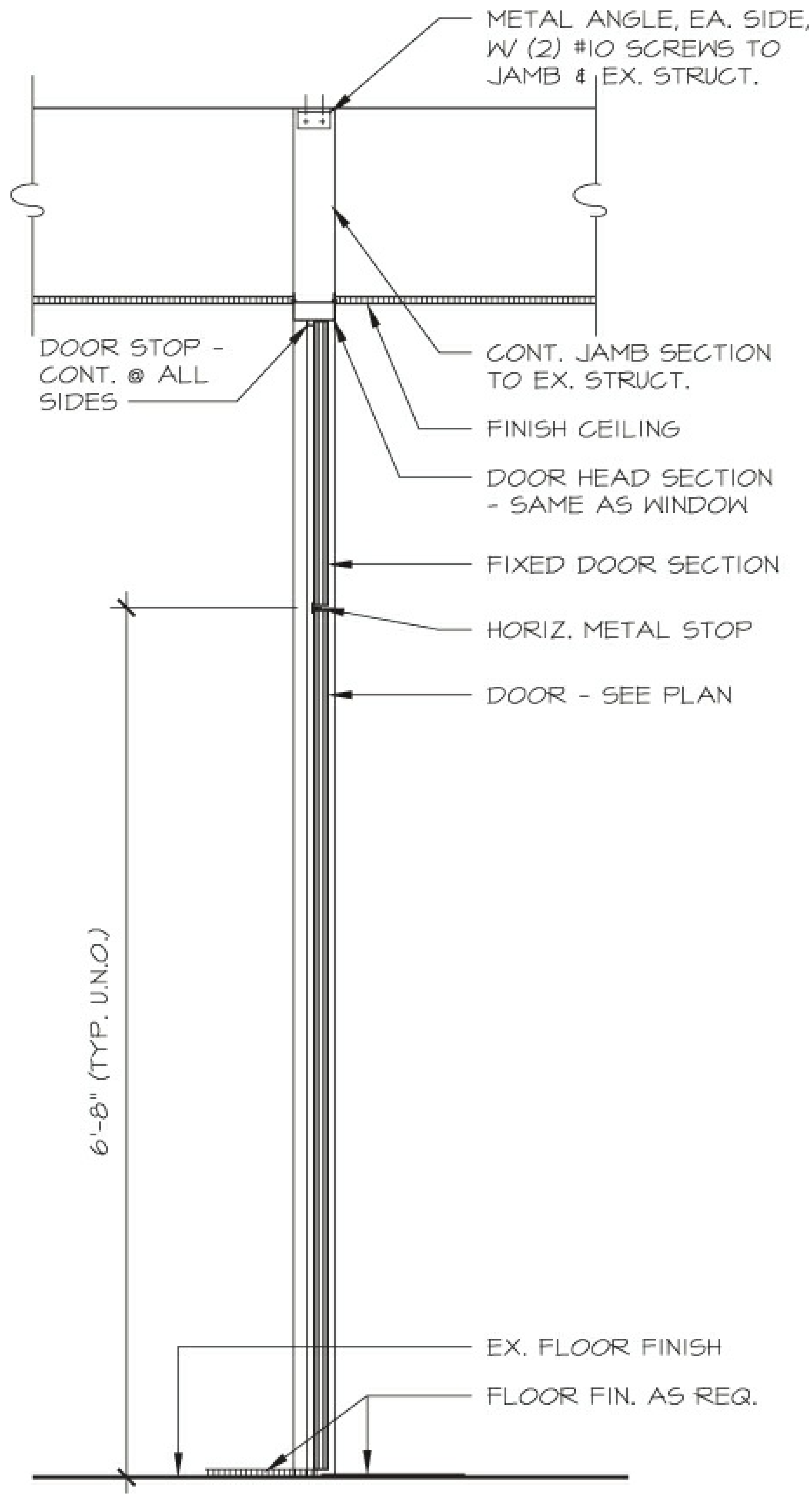


Figure 13.83 Interior door and fixed panel.

When restrooms abut an office space or other area where people assemble, it is recommended that the dividing walls be constructed with sound insulation batts between the metal studs. Resilient clips are used to attach the gypsum board to the metal studs. This non…load…bearing wall section is illustrated in Figure 13.84.

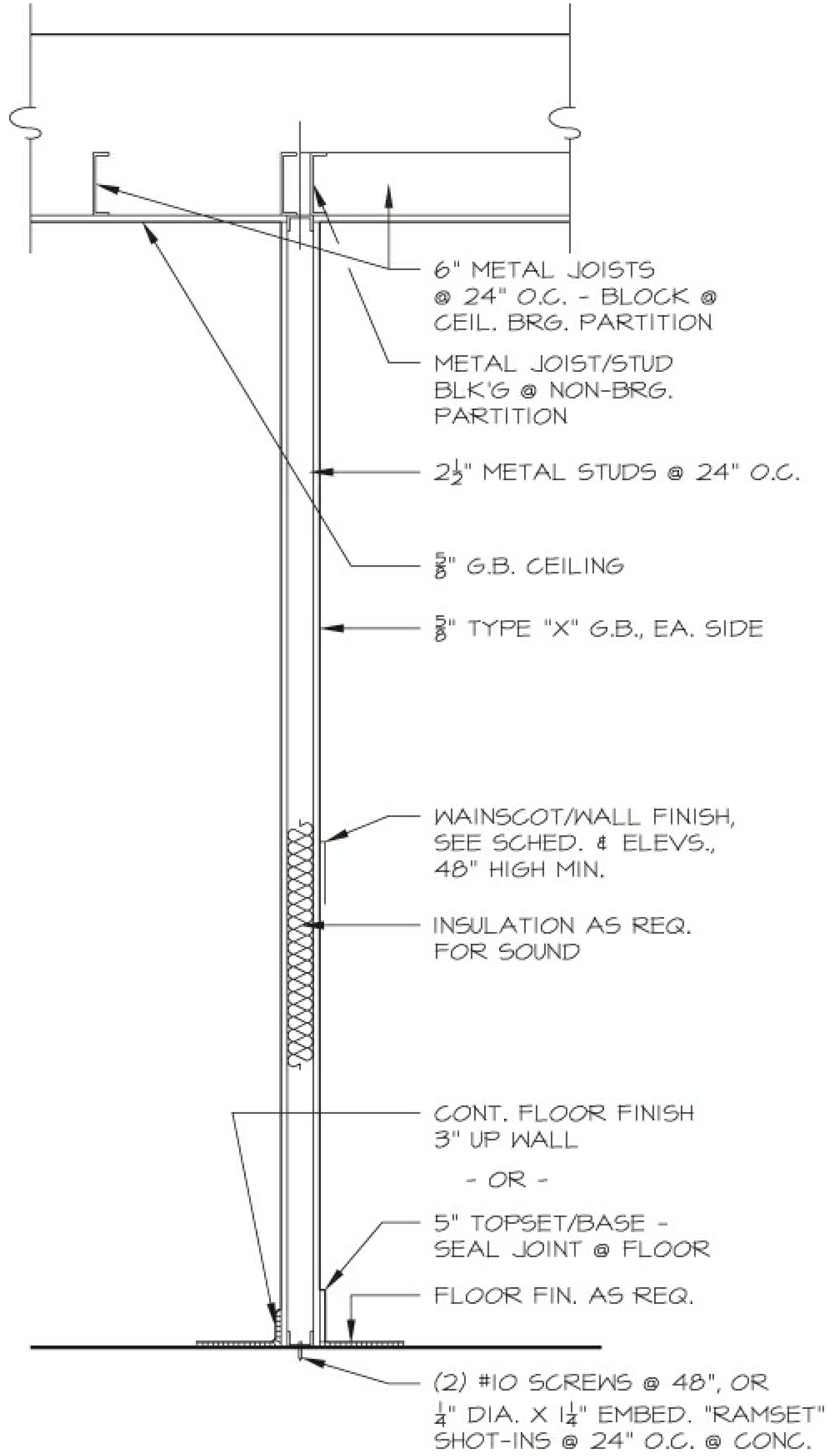


Figure 13.84 Restroom partition (non‐load‐bearing).

In cases where one‐hour fire‐rated division walls are required to meet a building code requirement, the walls will be constructed from the tenant floor to the floor system above. The wall sections in Figure 13.85 illustrate the materials required to satisfy the construction of a one‐hour non‐load‐bearing separation wall.

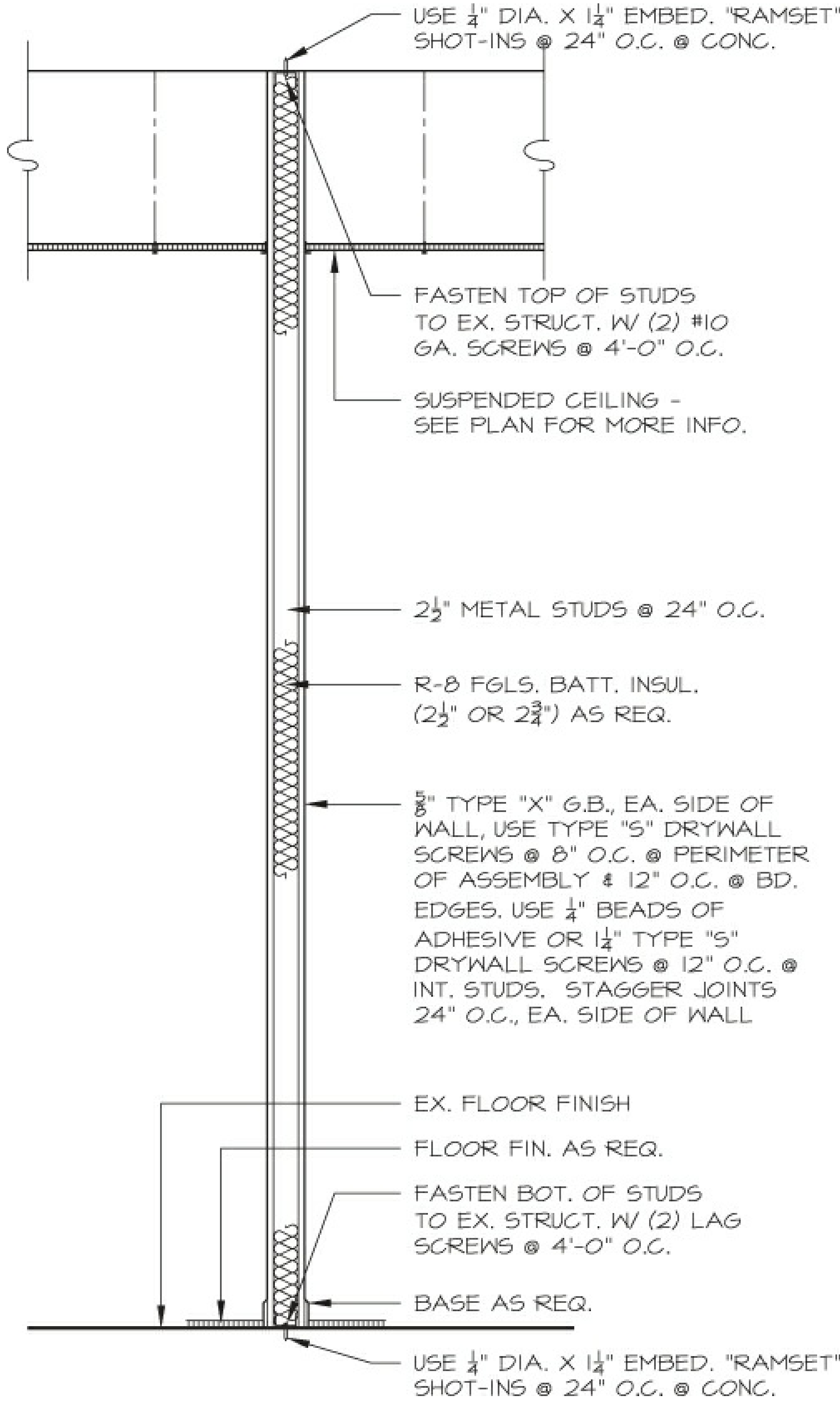


Figure 13.85 One…hour separation wall (non…load…bearing).

Key Terms

bare bones detail

bearing pressure

bearing surface

block out

brown coat

California frame

chase

chimney chase

color coat

compression

counterflashing

details

dumbwaiter

freehand sketches

freestyle

half…section

hearth

keynotes

keynoting

noncombustible

outlining

risers

scratch coat

sisal…kraft

stucco bumps

stucco mold

Styrofoam

tread

treads

wide flange

PART III
Tenant Improvement, Additions and Alteration, Historical Restoration, BIM via Revit, and Introduction to Design

Chapter 14 will address five different building types that make up a very large part of the construction industry: tenant improvement, additions and alteration to a structure, historical restoration, BIM via Revit, and introduction to design. One cannot totally comprehend the scope of architecture without some knowledge of the design process. To that end, we have requested the president of the American Institute of Architects (AIA) to include a short description of design development using one of the case studies, namely, the Madison office complex.

Chapter 15 describes the method being used to create working drawings (construction documents), by way of building information modeling (BIM), and introduction to design.

Chapter 14
ADDITIONS/ALTERATIONS, HISTORICAL PRESERVATION (RESTORATION), AND TENANT IMPROVEMENTS

This chapter will address four different building types that make up a very large part of the construction industry: additions to a structure, alterations to a structure, historical preservation, and tenant improvement, usually to buildings that are already built and altered by the owner to lease or rent. Prior to continuing this chapter, it would be a good idea to review the section on office standards found in Chapter 2.

ADDITIONS/ALTERATIONS

Additions and alterations will be discussed as two separate topics in this chapter; however, many professionals consider them synonymous. The examples in this chapter may be called additions, but in reality they are alterations.

Additions

Hopefully, the reader has experienced a family member, relative, or friend in the neighborhood adding a bathroom, family room, or bedroom onto their existing home. The experience may have been pleasant or downright frustrating for many reasons. Most architectural firms do not like to take on additions because the time expended is not worth the financial gain, so the project is usually passed on to a drafter. If the employee is extremely skilled, the addition project will be successful, but as expressed throughout this

text, the most common reason for a poor experience is the lack of a comprehensive coordination between the architect and/or assigned drafter, the client, and the contractor. Often, clients during this process will constantly change their minds about what they have started or, even worse, bypass the architect and deal directly with the contractor, who may or may not be licensed or correctly bonded.

As you go through an architectural education, you will find many of your colleagues involved in addition projects, which is a good thing; however, if you are doing this, you must be very well prepared.

Standards

Aside from the normal standards in reference to dimensioning, noting, and referencing, there will be new standards for identifying new walls, demolished walls, existing walls, and special, unique walls, such as walls built with angles, pierced with a sculpture, and possibly built with a new material. Look at Figure 14.1, which shows a partial floor plan with existing, new, and demolished walls. In Figure 14.2 you can see the representations of a new wall, which is drawn with two object lines and includes a slightly darker tone called poché. The second illustration shows walls that are to be demolished, identified by two hidden lines. The third type shows two solid lines that identify those walls that are existing. If the walls are other than wood…framed walls, we must be able to identify those walls and use a drawing symbol for masonry, steel, or concrete as shown in these examples. These standards can be used throughout this chapter.

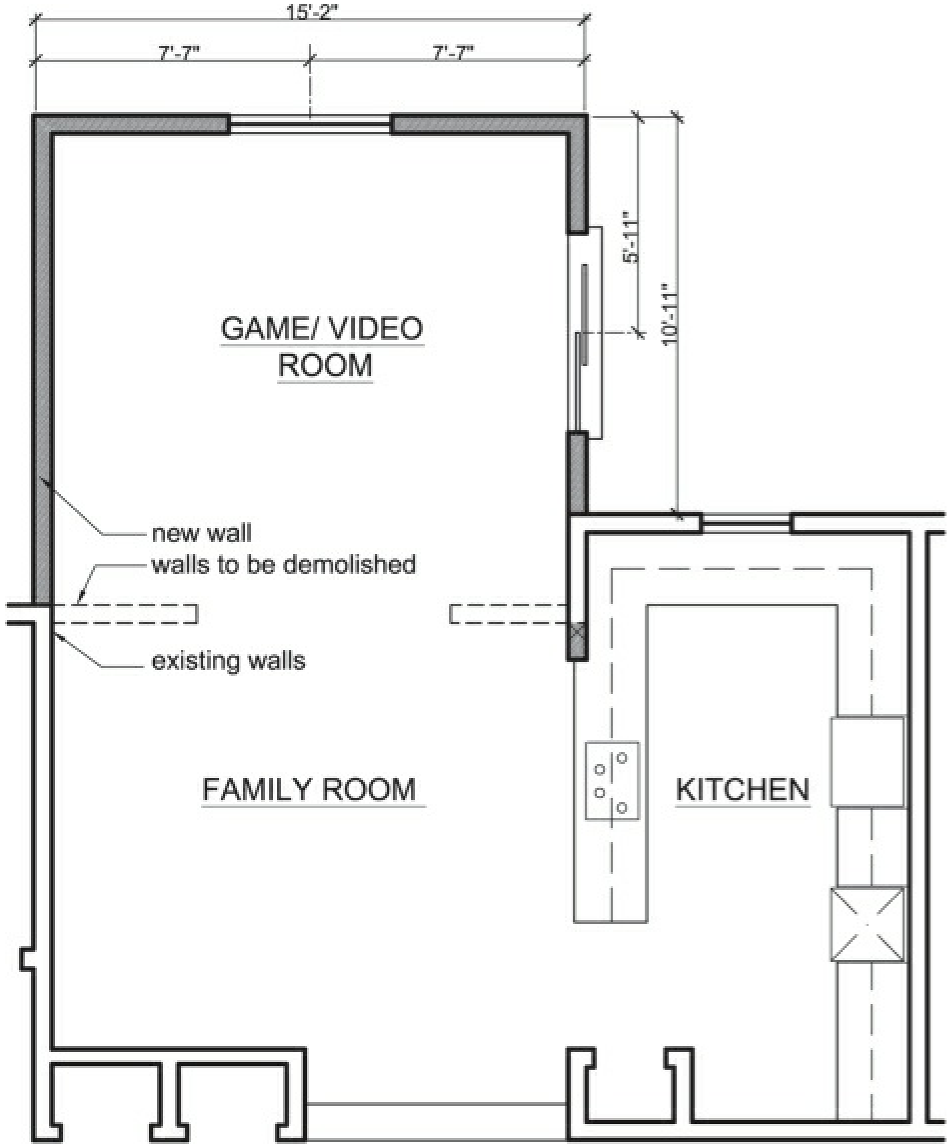


Figure 14.1 Floor plan showing existing, new, and demolished walls.

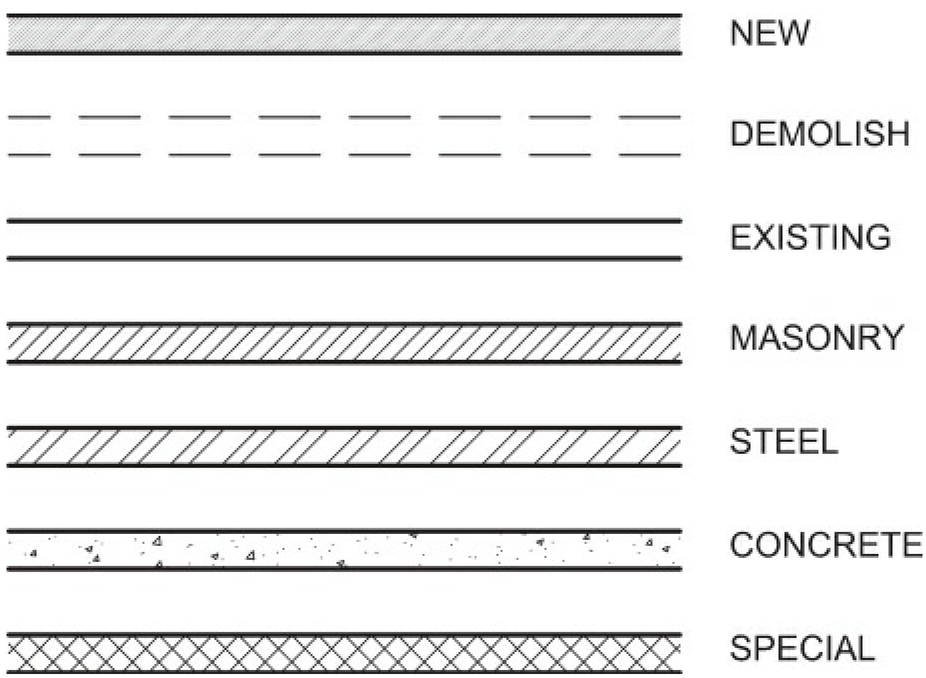


Figure 14.2 Wall types.

The architect/designer is required to use the same standards that were written in this

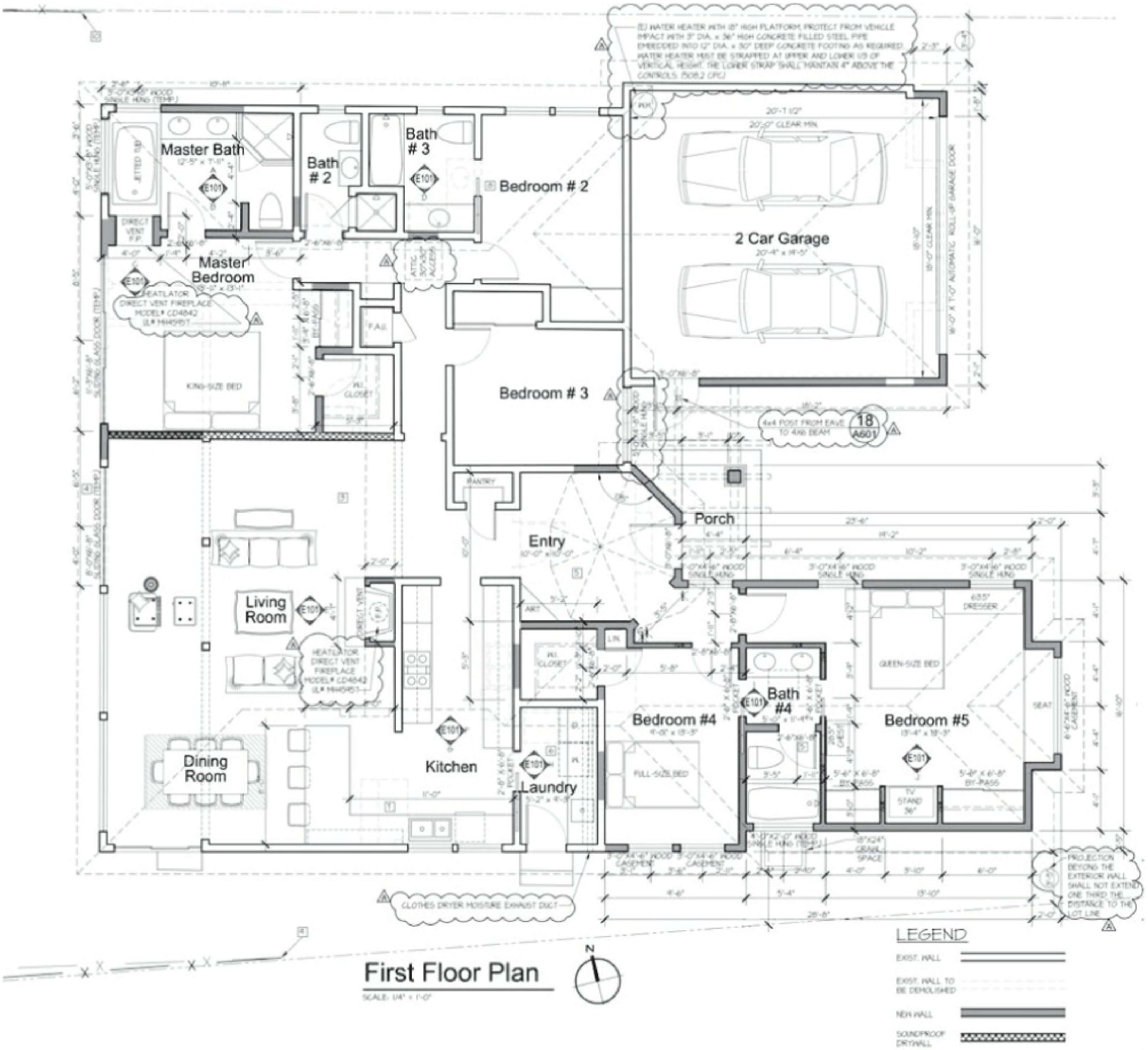
book for new structures. However, for an addition, one side of the dimension should always be placed on an existing wall. The larger the addition, the more complex the process becomes; unlike new buildings, you do not dimension to the stud line, but rather dimension to the finished side of the existing building, which will not be destroyed during construction. The same holds true for all other parts of the building. The foundation plan, the section, and the elevation will all have datums established throughout the construction. All datums must be measured in the field. Do not rely on drawings that were done to build the original building but rely on their actual dimensions.

Alterations

Alteration is the process of changing the structure on both the interior and exterior. The process is extremely simple; actually, the construction documents resemble additions, but the concentration is, as the title states, altering the structure. You may encounter a situation where you will not only alter a building but add to it as well.

As in all construction documents, dimensioning is critical. Establish a datum as a point reference from which all new changes are made. Always put yourself in the position of the workers in the field and try to visualize their task as you prepare the construction documents. By now, you must realize that this approach is sacred to all construction documents that you will be asked to prepare. We have included in each a case study. Look at these examples and try to understand the mind…set of the person who prepared them.

Case study Figures 14.3, 14.4, and 14.5 are unique in the sense that these preliminary drawings can be converted easily into working drawings, and can also help a client to understand how their furniture will fit into the final floor plan (Figure 14.3), with an alternative first…floor plan. Figure 14.5 is drawn in such a manner that it can be used as a graphic presentational drawing rapidly converted into a working drawing.



[Figure 14.3](#) Addition/Alteration case study floor plan.

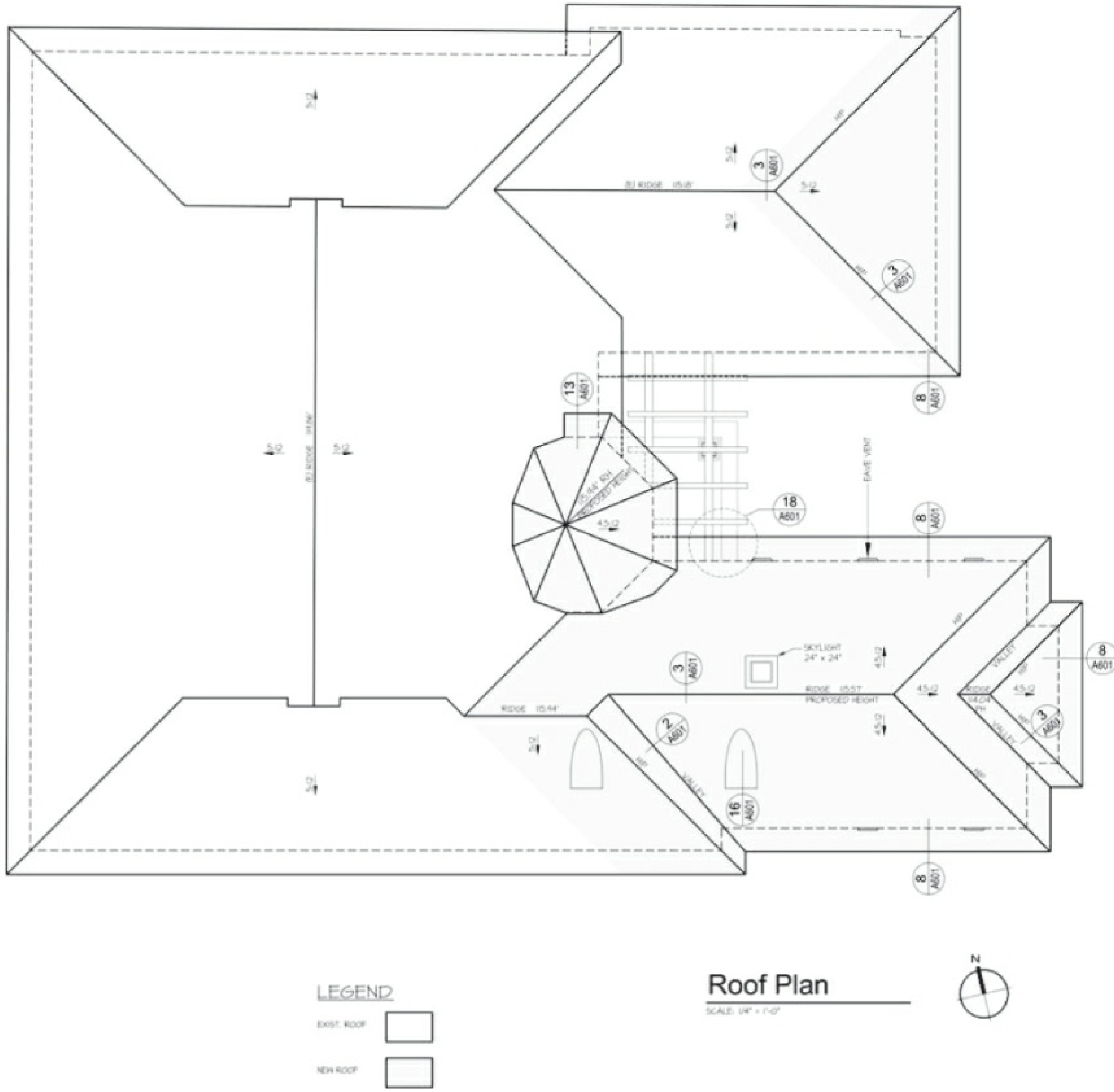


Figure 14.4 Addition/Alteration case study roof plan.

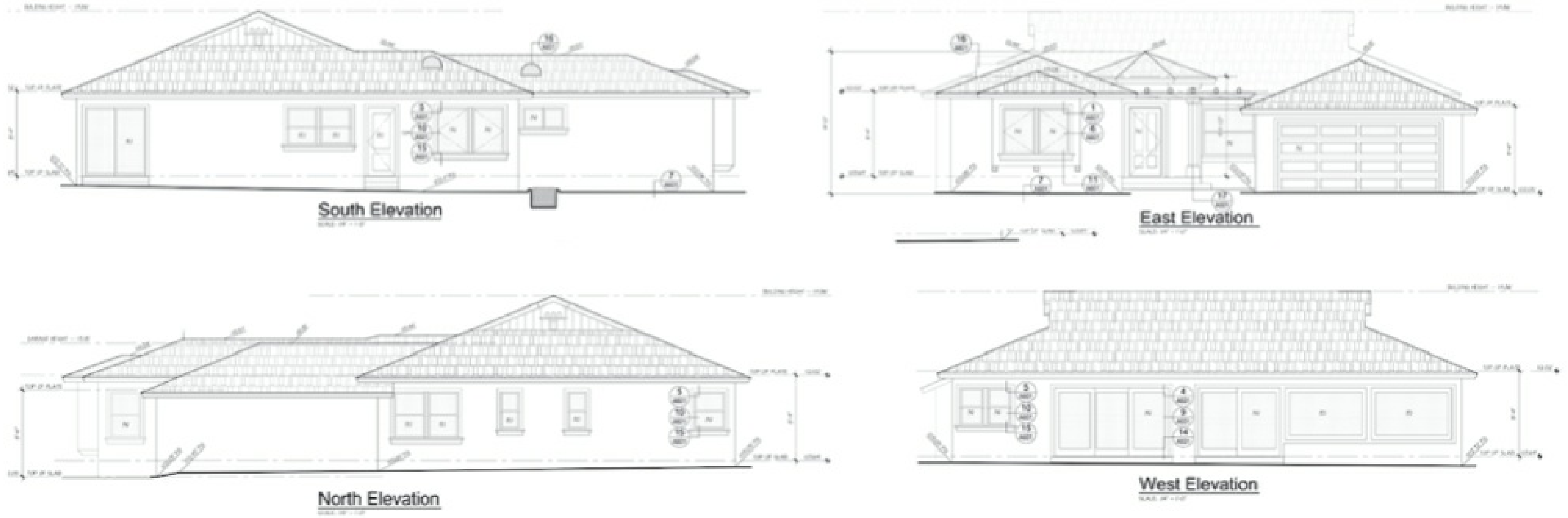


Figure 14.5 Addition/Alteration case study elevations.

Historical Restoration

One of the most difficult and precious drawings that you will ever encounter is historical restoration, the process of preserving a masterpiece of architecture. The structure may be hundreds of years old. It was deemed worth salvaging by our culture to preserve a moment in our lives where even the method of construction may have been totally different than it is presently. Historical restoration is also a way of honoring the designer's concept and attitude. Restoration is more than a matter of patching and temporarily fixing damage to part of the structure, repairing structural damage while maintaining the integrity of the building, or repairing a portion of the building that is deteriorating without affecting the nature of the design. It is a monumental task to understand the various components of the preservation while maintaining the culture of our people. Much research has to be done before one engages in construction documents because it is so important to understand why the building is being restored.

It may begin with the major backbone of the building and then reservicing entire facade. Historical restoration may include engaging a totally new technique, such as photography. Digital photography has made it practical since the computer can produce an image immediately. You can then produce an overlay onto the photograph and produce a computer image of what needs to be done to the building. See Figure 14.6.

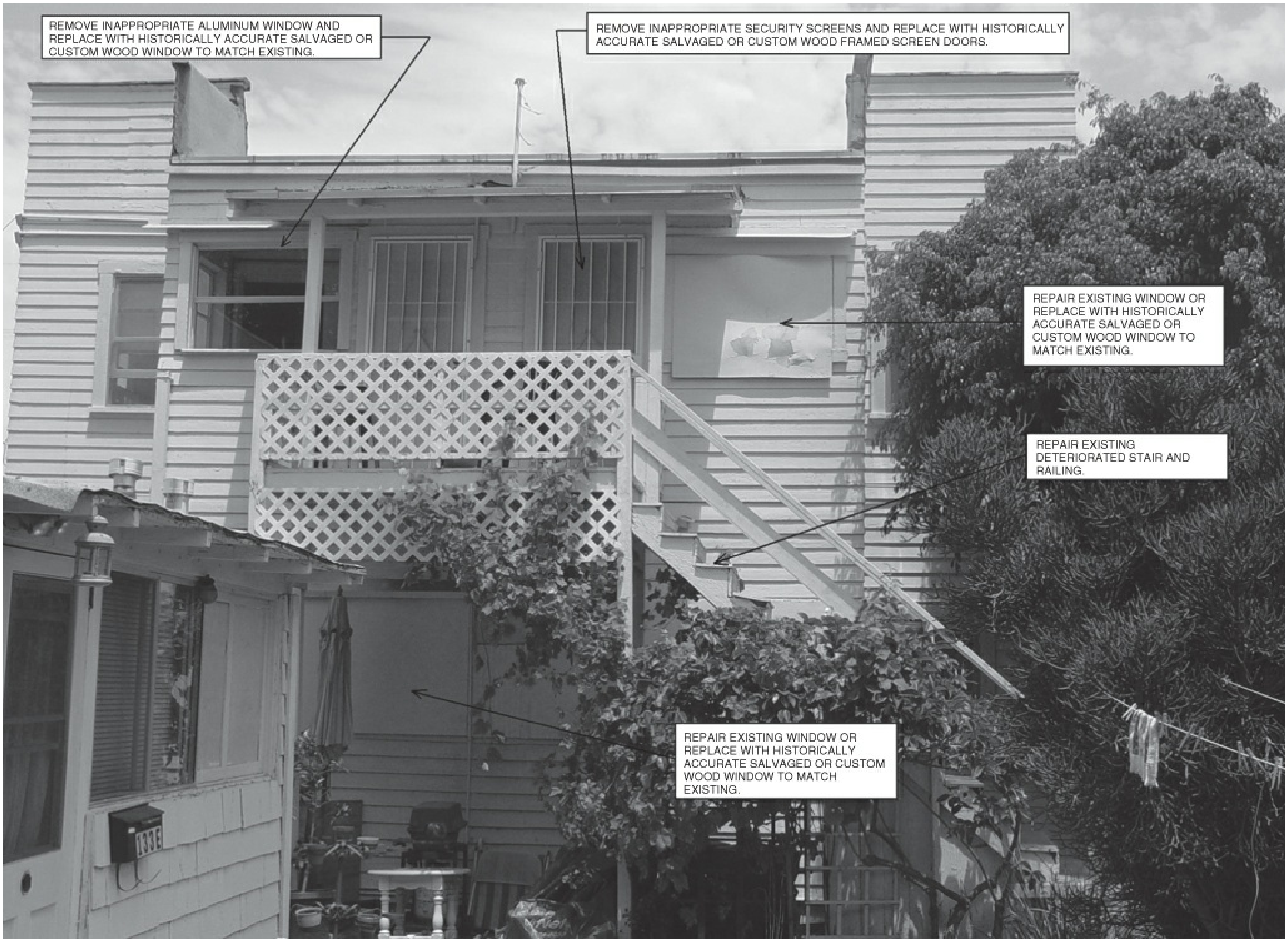


Figure 14.6 Historical restoration case study.

Photography/Drafting

It is particularly inventive to use digital photography for drawing both interior and exterior elevations. This technique has found a home in historical restoration and older tenant improvement projects. Four examples can be found in Figure 14.6.

TENANT IMPROVEMENT INTRODUCTION

Unlike other buildings described in this book, **tenant improvement** (also called **space planning**) is not about how to draw construction documents for a structure; rather, it is about the planning of nonresidential buildings. The building is directly built and the interior space is leased, rented, or sold for occupancy as a condominium (i.e., shared space owned by a group). This will be demonstrated by the use of two existing office buildings.

Tenant Improvement A, which has a large, undeveloped, open space with nonrequired travel and exit corridors yet to be constructed, will illustrate the necessary design

procedures to satisfy corridor and exit travel to an existing lobby and two stairwells. Construction assemblies for exit corridor walls will be detailed to satisfy specific building code requirements.

Three tenant suite spaces will be illustrated as an example of the partial development for a large floor area. Exit requirements for these three spaces will be discussed, with an example of a tenant separation…wall assembly that will be constructed between the various suites. Building A and its illustrations provide an example of open space planning for tenant suites, required exiting, and wall construction requirements. Working drawings for the tenant suites are not illustrated.

The **improvement** of a space, in most cases, is defined as the construction of the interior walls, doors, windows, ceilings, movable partitions, and specialty items that may be required for the function of the tenant's daily tasks. Improvements also include cabinetry, hardware, plumbing fixtures, finished floors, carpeting, and finished painting. Such improvement usually includes supplementary heating, ventilating, and air…conditioning systems, sized and installed for a designated space or area.

Internal planning deals with the task areas enclosed within the walls by various construction assemblies. The tenant—that is, the user—will provide the necessary design criteria for the designer to plan the various task areas. Design criteria may include such information as room use, room sizes, and toilet facilities; electrical, telephone, and equipment locations; special lighting requirements; and desired floor, wall, and ceiling finishes.

In most cases, the designer or drafter will plan within a designated area of an existing structure, although they may plan an entire floor area. Generally, designated areas are found in multitenant buildings and vary in square footage. It should be noted that tenant improvement may also entail redeveloping an existing constructed space. This situation requires that the room dimensions, lighting fixtures, structural components, equipment locations, and existing electrical and mechanical locations be verified before the preliminary design process begins.

EXISTING BUILDINGS

It is imperative that the first step in drafting a set of construction documents for a tenant improvement project be production of a drawing called **as built**. This drawing features the dimensions of the structure as it stands; hence the name “as built.”

Often, the original set of construction documents is available to the tenant improvement drafter, but the parameters of the inside of the structure must be remeasured. The reason is that a structure is rarely built to the precise size shown on the original drawing.

The as…built drawing becomes the datum or base for the entire set of construction documents from this point on, whether drawn by hand or on the computer. If the original set of documents is available, the as…built drawing is derived by making the necessary

corrections on the existing drawings: moving walls, column locations, and so forth.

EXISTING FLOOR LEVEL—MADISON…B BUILDING

With a given floor plan for an existing three…story undeveloped structure, we can explore potential floor areas for tenant use. Figure 14.7 illustrates the second…floor level of this building. As illustrated, the existing stairwells, men's and women's toilet facilities, elevator shaft, telephone room, and janitor's room have been constructed according to building code requirements. The first prerequisite is to establish a corridor that satisfies all exit requirements of the governing building and fire codes.

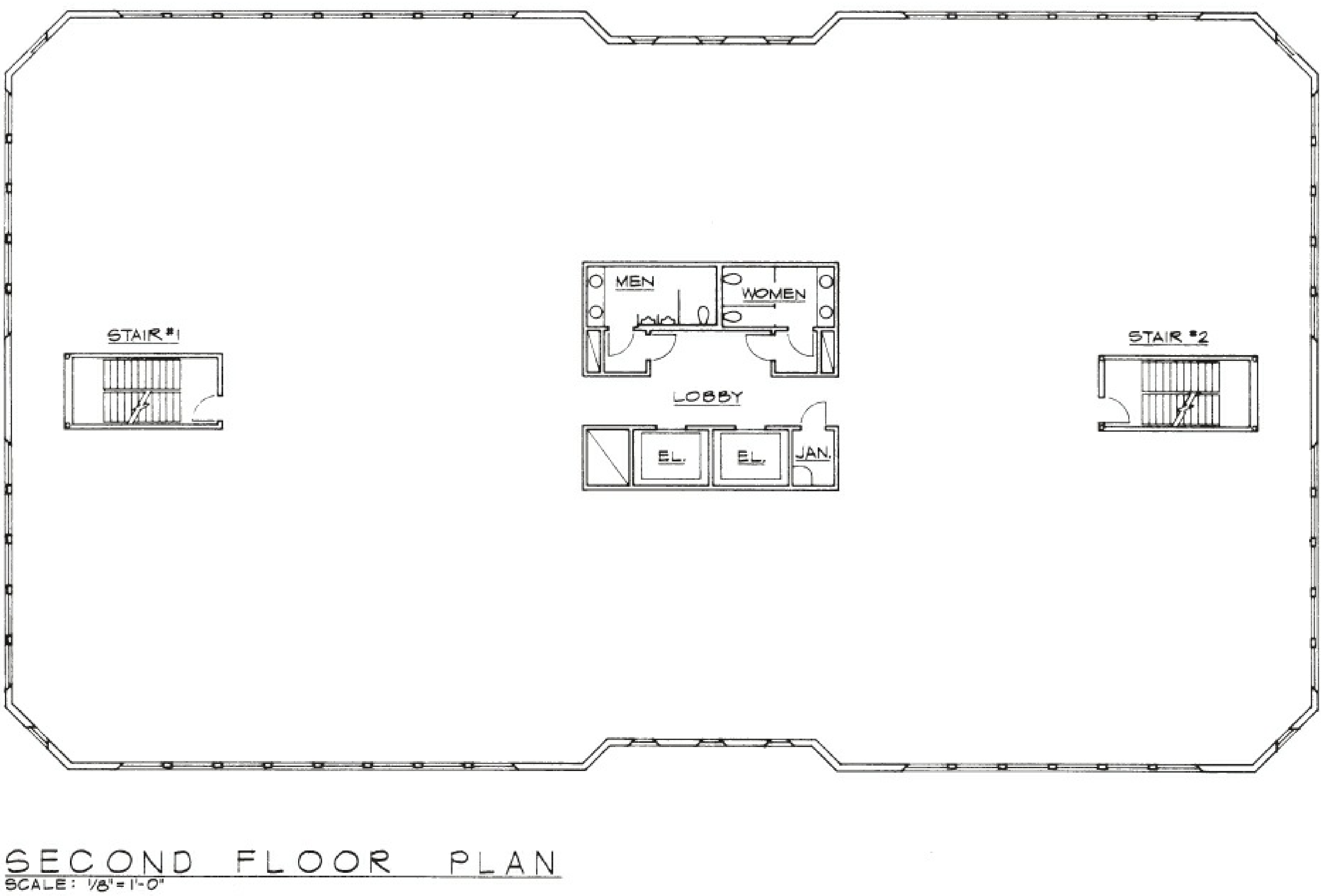


Figure 14.7 Existing undeveloped floor.

Exit Corridors

Figure 14.8 shows a pictorial with a corridor that satisfies code relative to width and location. The walls and ceiling construction of the corridor must meet the requirements for a one…hour fire…rated assembly. A detailed construction section of this assembly is depicted in Figure 14.9. Metal studs are illustrated; however, wood studs may be used if they meet the governing fire code requirements. It should be noted that most building codes require exit doors into the corridor to have a 20…minute fire…rated assembly, as

designated in the corridor section in Figure 14.9. As described earlier, it is essential that you verify the dimensions by remeasuring the structure. Even if you have the original drawings of the structure, you must verify its size, window and door locations, stairs, elevator location, and even the corridor locations. You will always discover that changes in size and location of existing walls occurred during construction.

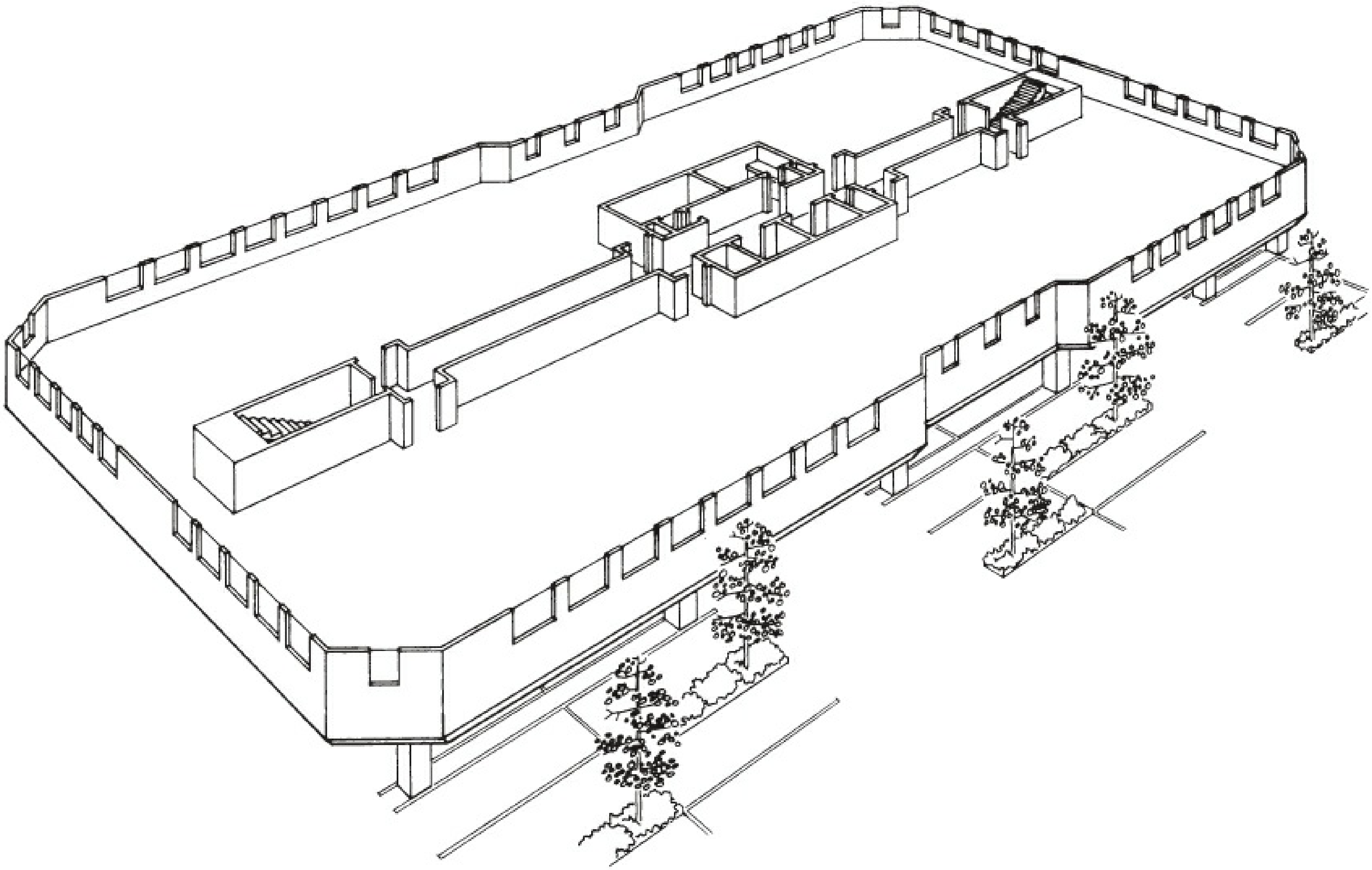


Figure 14.8 Pictorial view of corridor.

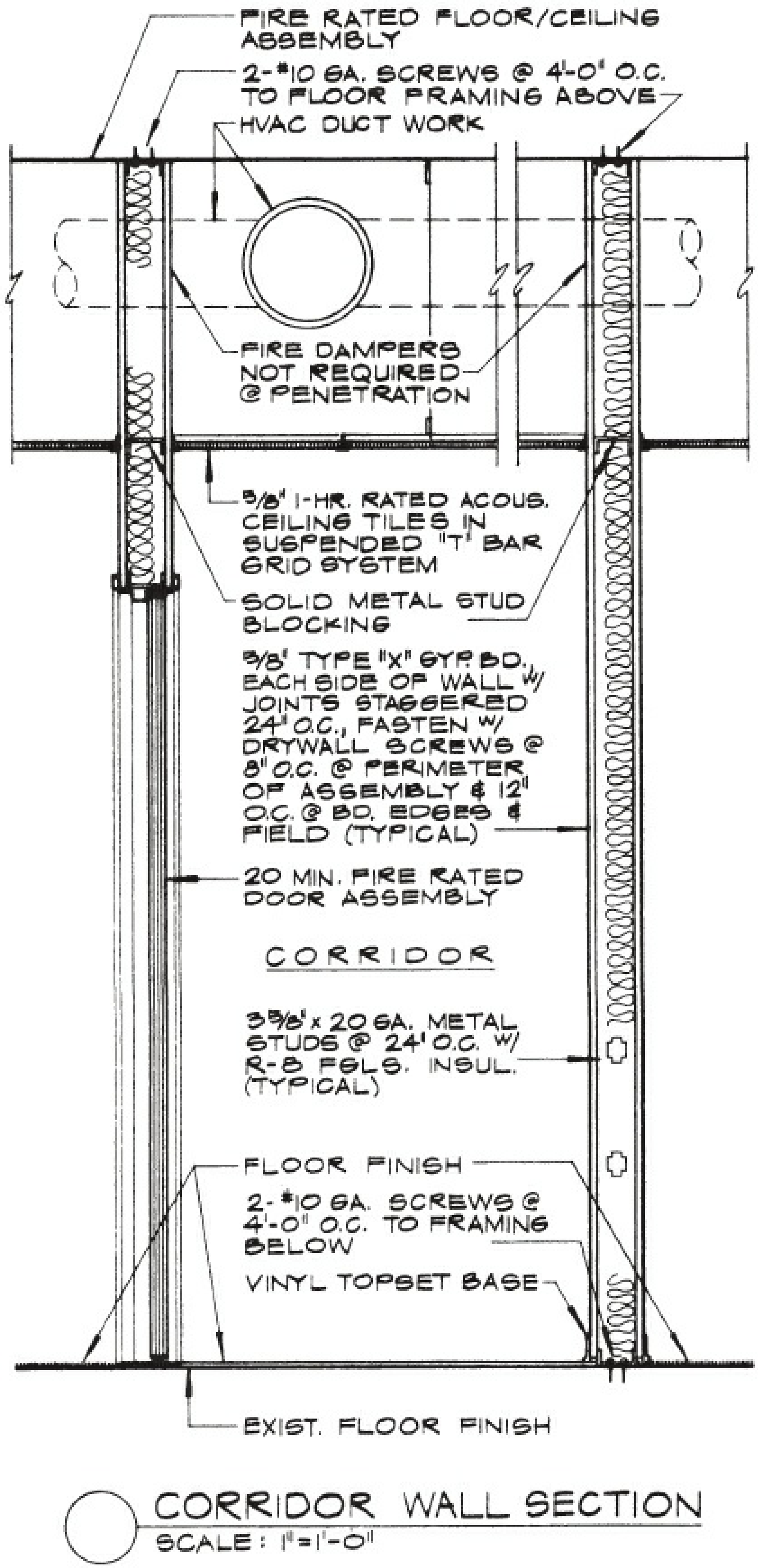


Figure 14.9 Fire‐rated corridor construction.

Tenant Areas

After an exit corridor that will be used by various tenants on this floor is established, designated areas or floor areas required to satisfy the particular users' space requirements may now be formulated. In dealing with a tenant's area requirements, the designer must

adhere to building code criteria relative to the number of exits required for a specific area.

An example of required exiting is depicted in Figure 14.10, which shows that Suite A has a floor area of 3,200 square feet. Because of this suite's area and occupant load, the building code requires two exit doors to the corridor. According to the code, these two doors must be separated by a distance of one…half the length of the diagonal dimension of this area. See Figure 14.10. Figure 14.11 illustrates this condition pictorially. This code requirement will be a primary factor in the internal planning of this suite. As shown in Figure 14.12, the floor area of Suite C is less than 1600 square feet; thus, according to the building code, this suite requires only one exit to the common corridor. It should be noted that additional toilet facilities may be required by the building code authorities, predicated on the number of employees occupying the particular suites. This would be a planning factor for the tenant improvement design.

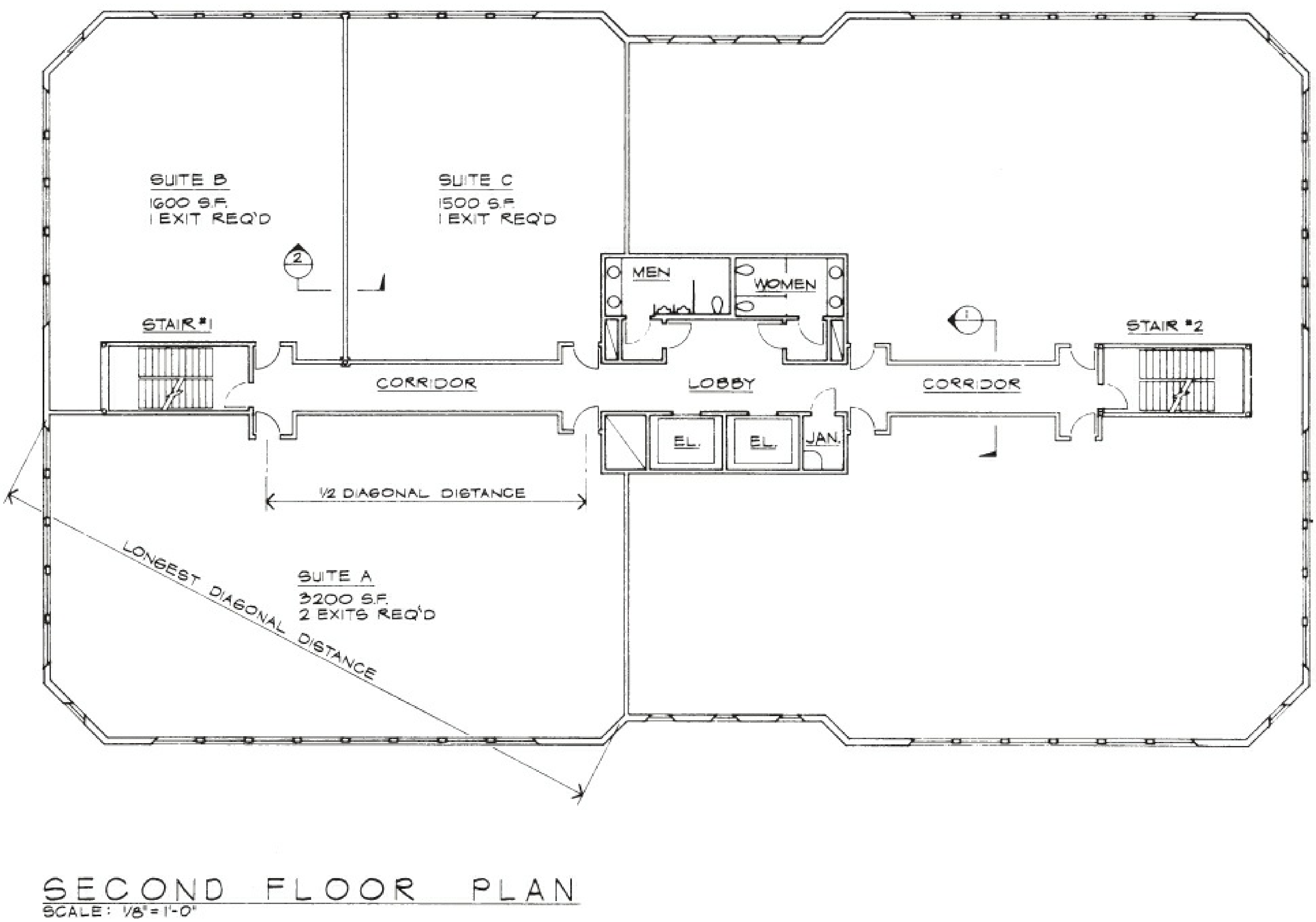


Figure 14.10 Suites A, B, and C.

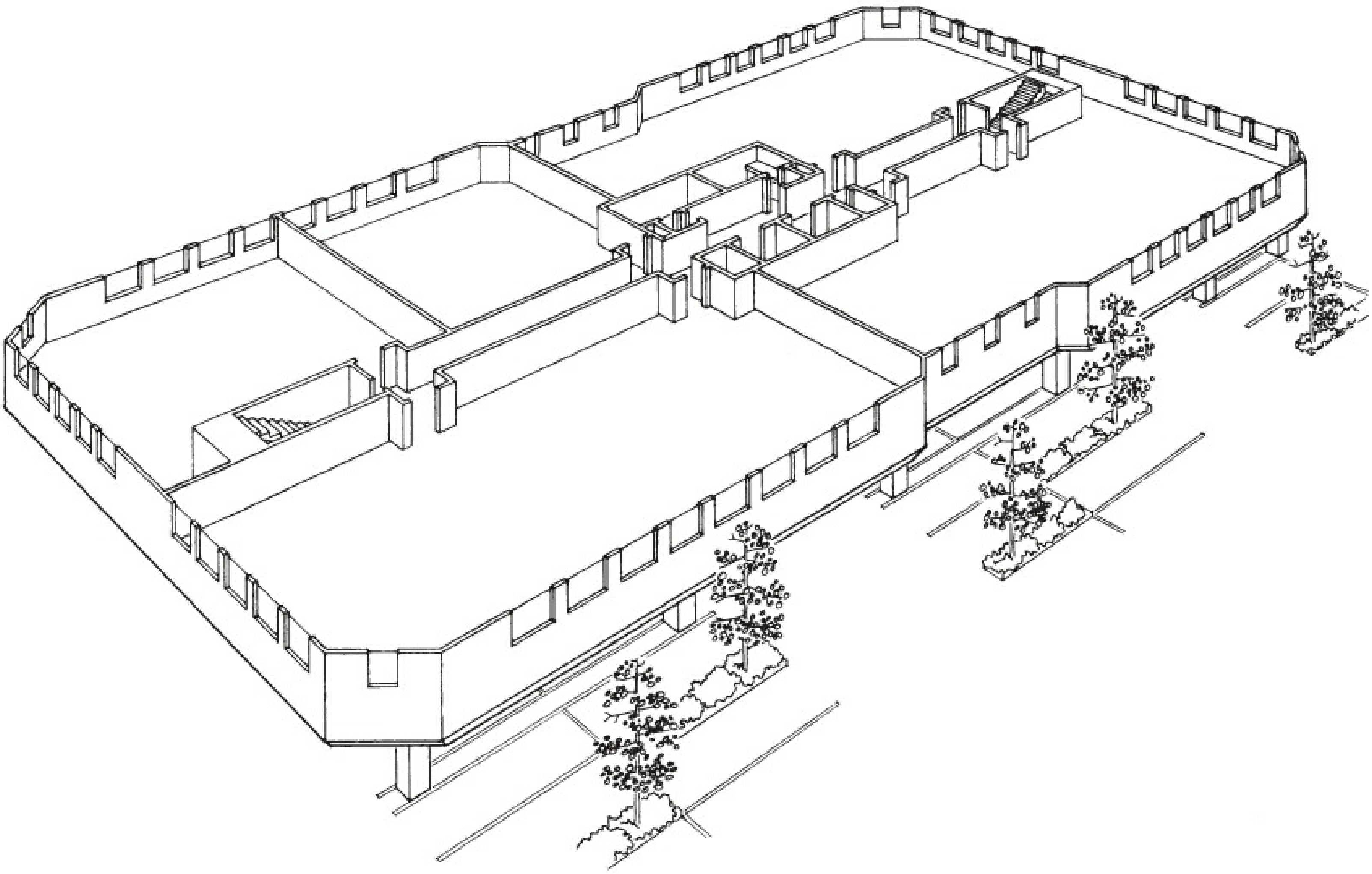


Figure 14.11 Pictorial view of tenant separation walls.

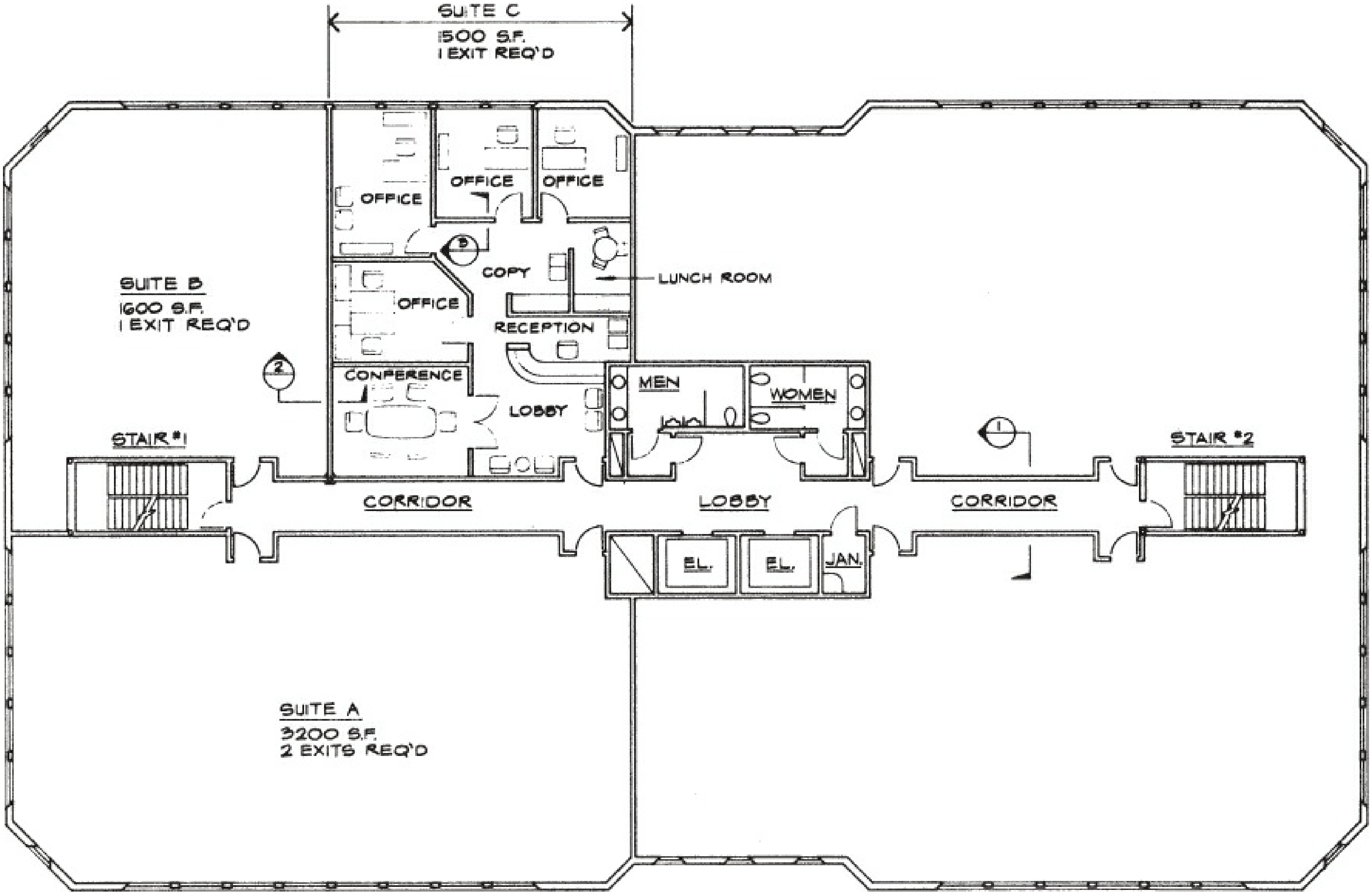


Figure 14.12 Floor plan—Suite C.

Tenant Separation Wall

When there are numerous tenants on a given floor level, local building department authorities and building codes may require a one‐hour fire‐rated wall assembly between each tenant area. Figure 14.13 illustrates a non‐load‐bearing, one‐hour fire‐rated wall assembly incorporating metal studs and gypsum board. A **non‐load‐bearing wall** is one that does not support ceiling or floor weight from above or any other weight factors distributed to this wall. Wall insulation is shown as a means to decrease noise transmission between the various tenants.

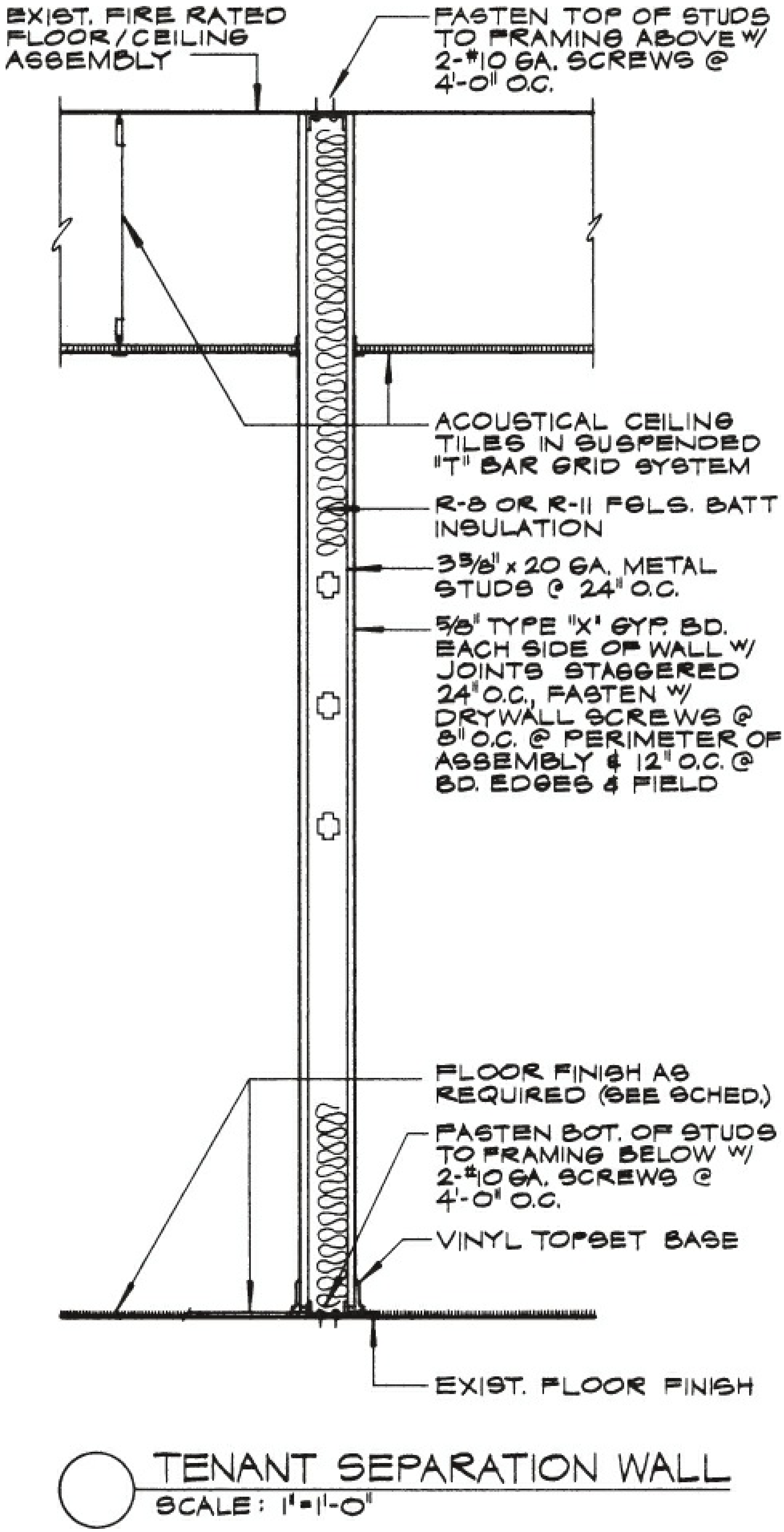


Figure 14.13 Tenant separation wall.

The construction techniques for a wall assembly used within a specific suite may vary.

Figure 14.14 illustrates an example of a wall partition section used in offices for tenant improvements. Note that this wall partition extends to the roof framing in order to reduce the sound transmission between the various rooms and halls, and maintains a secure office condition.

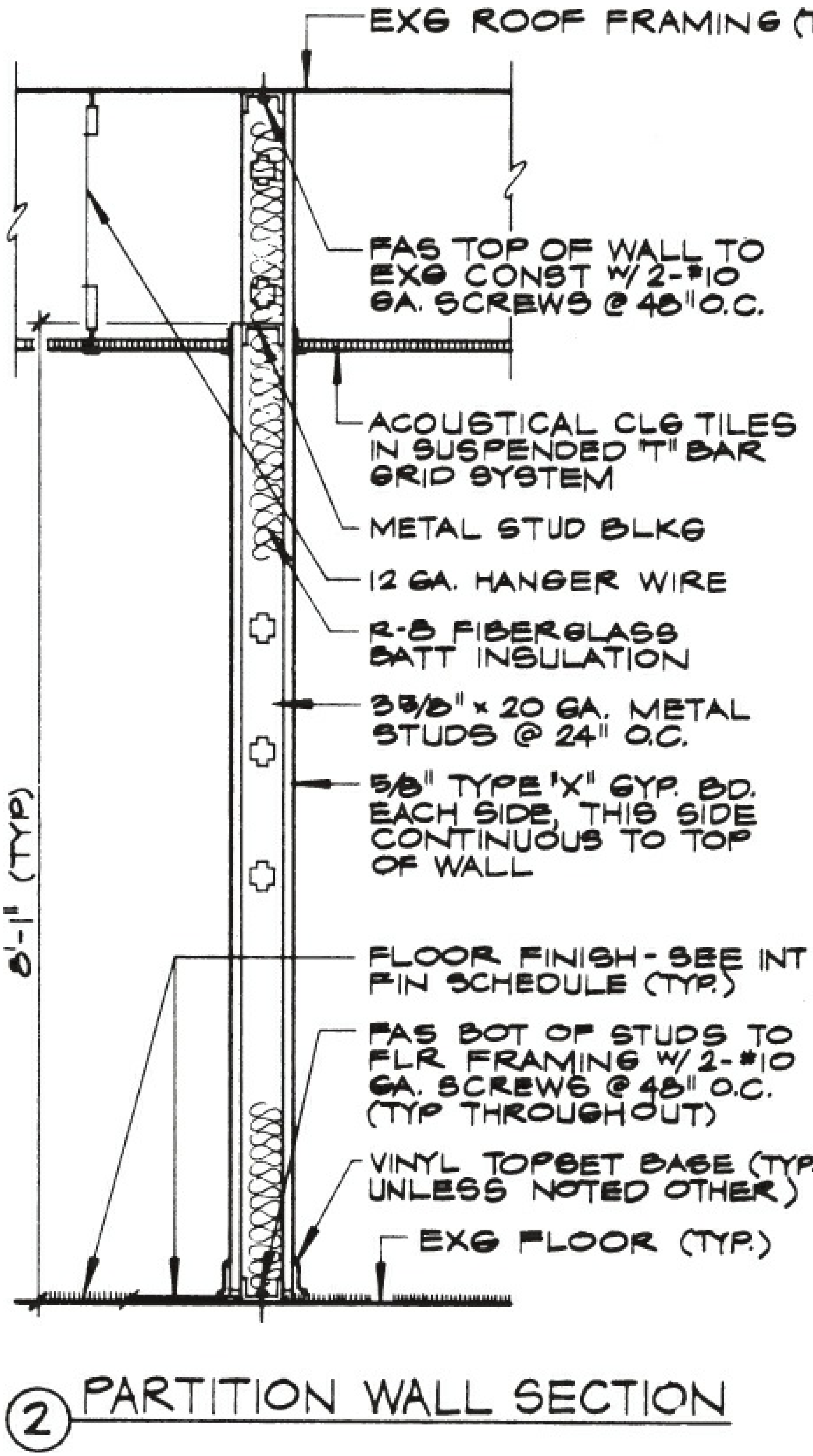


Figure 14.14 Partition wall section.

Building A has been used to illustrate the basic procedures and requirements for potential suite developments within a large, existing, undeveloped floor space. Building B, in

contrast, will illustrate the procedures implemented in an architect's office for a tenant improvement design and the completion of working drawings.

DEVELOPMENT OF WORKING DRAWINGS—KEIM BUILDING

As discussed earlier, internal suite planning is developed from the tenant's criteria that satisfy the needs for its business function.

In planning a given undeveloped space on the second floor of an existing office building, the designer will visit the space and verify the structural components, such as columns and beam heights. The designer and staff will take measurements to verify existing inside area dimensions, column locations, window sizes, and the spacing of window mullions. In some cases, mechanical, electrical, and/or plumbing components, such as exhaust ducts, roof drainage pipes, and water lines for domestic and mechanical use, may be located in this undeveloped space. If so, they should be plotted on the initial plan layout.

Figure 14.15 shows the undeveloped floor plan of an existing second‐floor level of a two‐story office building. The process of making working drawings for the improvement of Suite 201 starts with the tenant requirements and verification of the existing space and conditions. Note the existing steel columns, stairs, mechanical shafts, roof drain lines, windows, and window mullion locations.

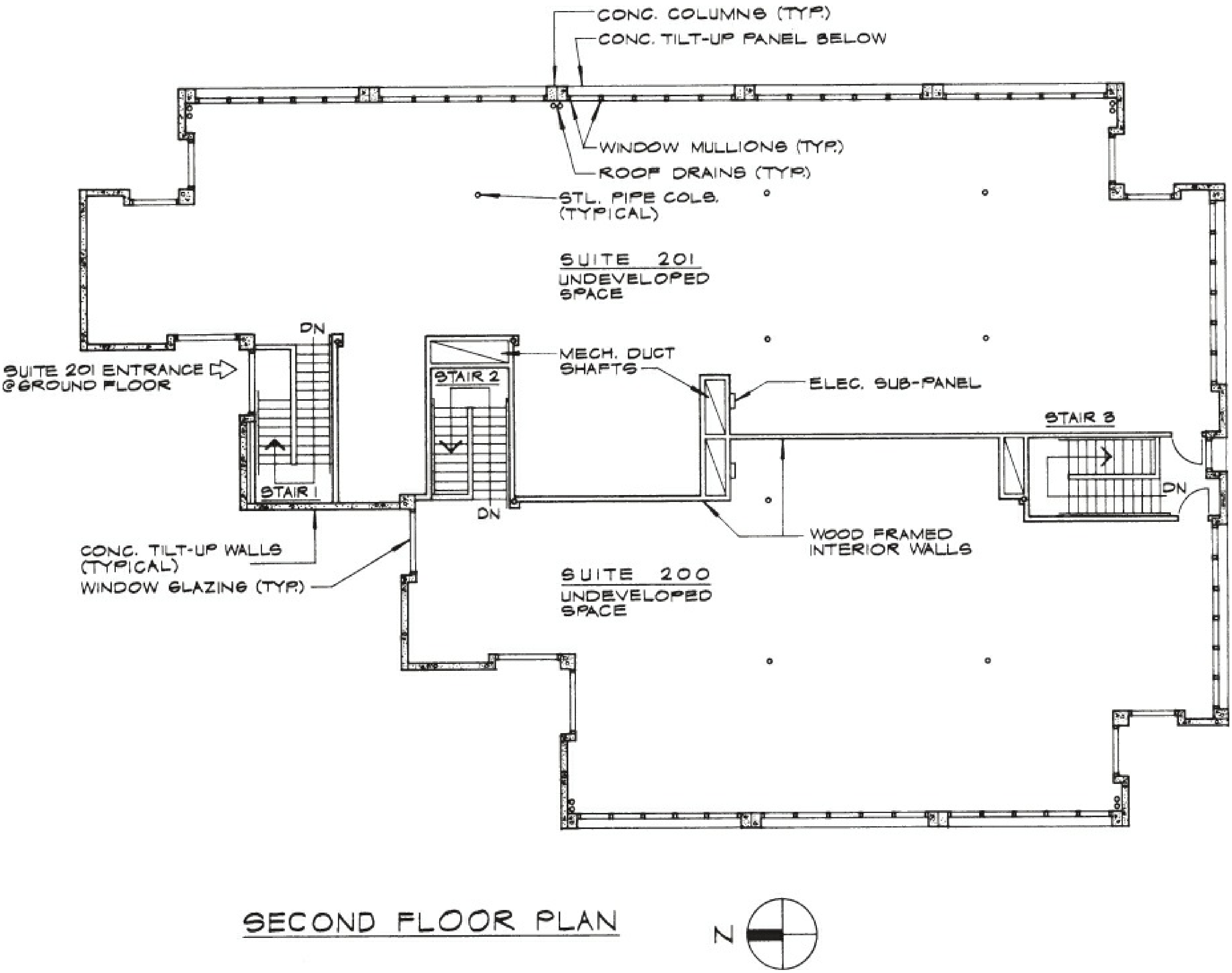


Figure 14.15 Undeveloped floor area plan—Building B.

Planning of Task Areas

The tenant for this designated space deals with graphic communications and has provided the designer with a list of the various rooms needed, their preferred sizes, their use(s), and their relationships to each other. This communication between client and architect becomes the program for the project.

Schematic Study

The rooms specified by the tenant include a reception area, three offices, a conference room, a large studio accommodating numerous drawing boards, a small studio for airbrush media, a copy room, and a storage room. The tenant also desired a coffee area with cabinets and sink and a service area for cleanup of art implements. The location of walls and rough plumbing for the restrooms already exist; therefore, these rooms require only finishing.

Given the preceding information dealing with specific task areas, schematic studies can now begin in order to show tentative room locations and their relationship to one another. Figure 14.16 illustrates a conceptual floor plan in schematic form, which will be used in discussing the various areas and their locations with the tenant.

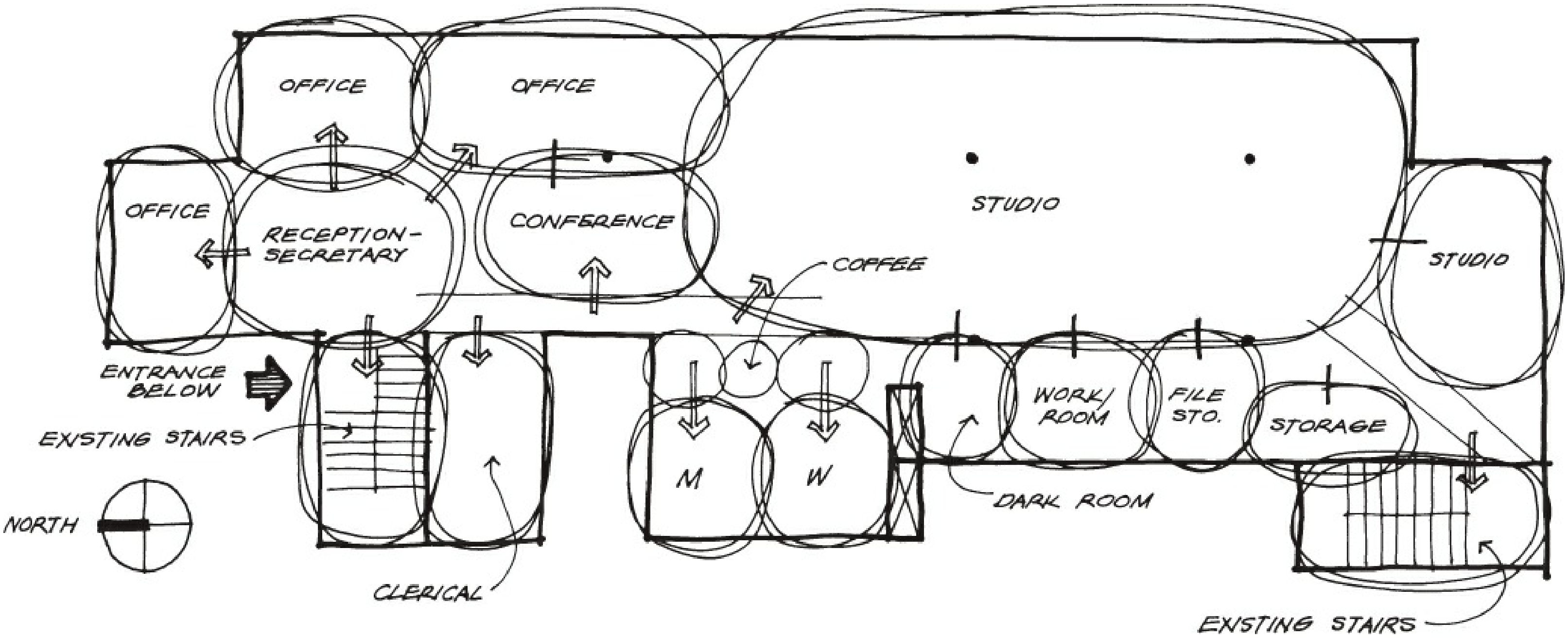


Figure 14.16 Schematic study.

Following this procedure, a preliminary floor plan will be developed to scale, including suggested locations for the required furniture. This drawing may be done in freehand, as is shown in Figure 14.17.

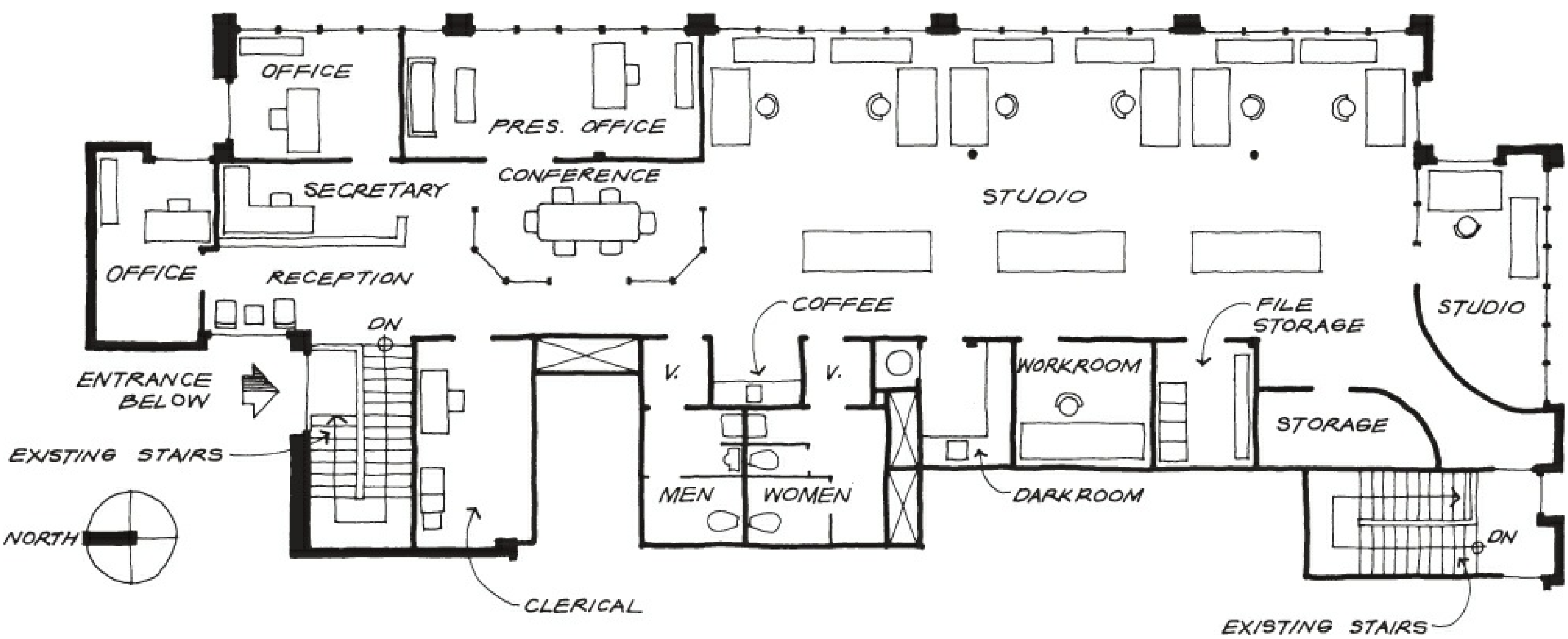


Figure 14.17 Preliminary floor plan.

Upon the tenant's acceptance of the preliminary plan, a plan is created to show the required room locations and sizes (see Figure 14.18). Note that the division walls between the offices, adjacent to the exterior wall with windows and mullions, are located to intersect at the window mullions and concrete column locations. This eliminates the

problem of a division wall butting into a glass area, which obviously would be undesirable.

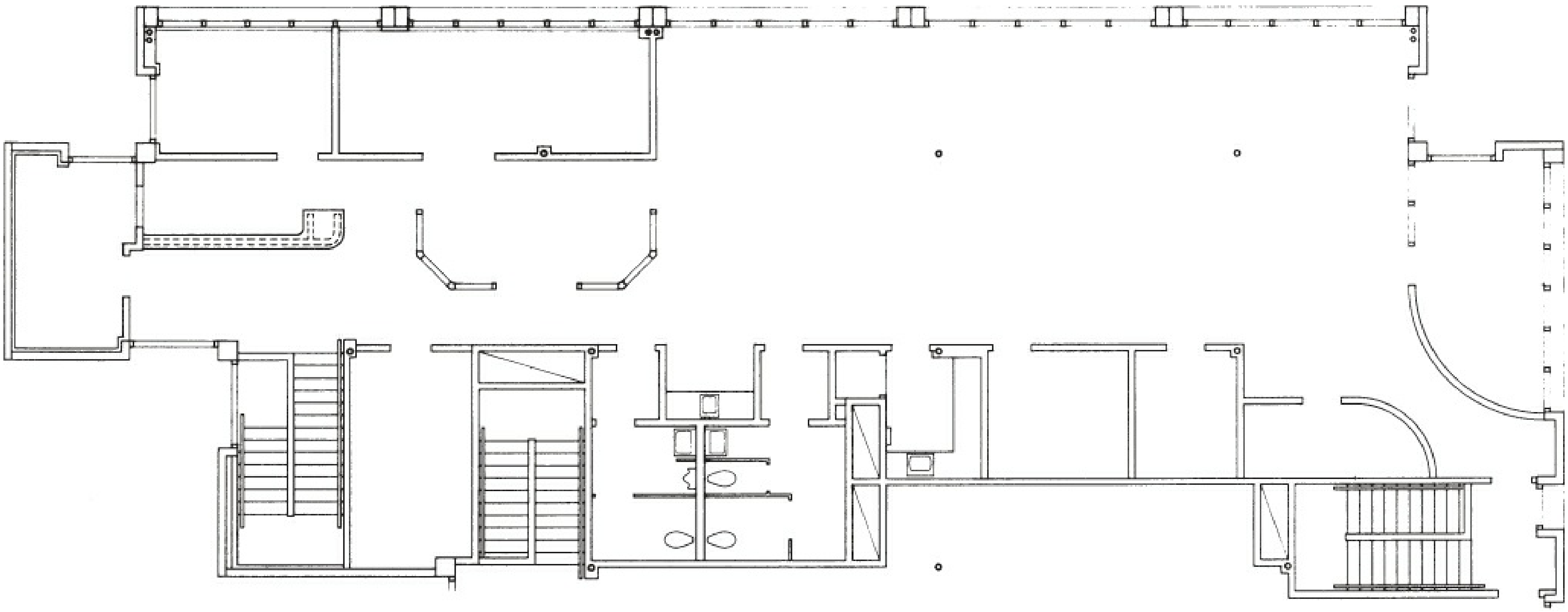


Figure 14.18 Wall development plan.

The location of existing structural columns presents planning obstacles in relation to various spaces. It would be desirable to conceal a column within a division wall wherever possible. Note in Figure 14.18 that some of the existing steel pipe columns have been incorporated into various wall locations.

Interior Partition Wall Construction

Now that the locations of walls, doors, and windows have been established, details for the construction of these components will be designed as a part of the working drawings for this tenant improvement project.

For the sake of clarity, it is recommended that existing walls and new walls be delineated differently. For example, the existing walls can be drawn with two separate lines, and new walls with two lines pochéd or hatched, so that viewers can distinguish between them. Wall symbols can be used for reference. Note the wall shading and wall symbols in Figure 14.19. The main structural consideration in detailing non…bearing interior walls is to provide lateral stability. For this assembly, the wall will be braced with metal struts in compression from the top of the wall to the existing structural members above, as shown in Figure 14.20. A metal strut used for lateral wall support is shown in the photograph in Figure 14.21. This wall assembly uses steel studs for the wall structure; however, wood studs are also used for partition wall assemblies. A photograph of steel stud framing members is shown in Figure 14.22. The finish ceiling members will terminate at each wall partition because the use of this wall assembly dictates that walls be constructed before the ceiling is finished. This method provides more design flexibility for the ceiling and lighting layout, which is illustrated and discussed later in regard to the design and layout of the ceiling plan. Figure 14.20 illustrates a suspended ceiling, which is assembled with 12…gauge hanger wires and metal runners supporting the finish ceiling material. In

regions of the country where there is earthquake activity, the suspended ceiling areas are braced to minimize lateral movement. One method is shown in Figure 14.20, where 12… gauge wire at a 45° angle is assembled in a grid pattern, providing lateral stability for the suspended ceiling.

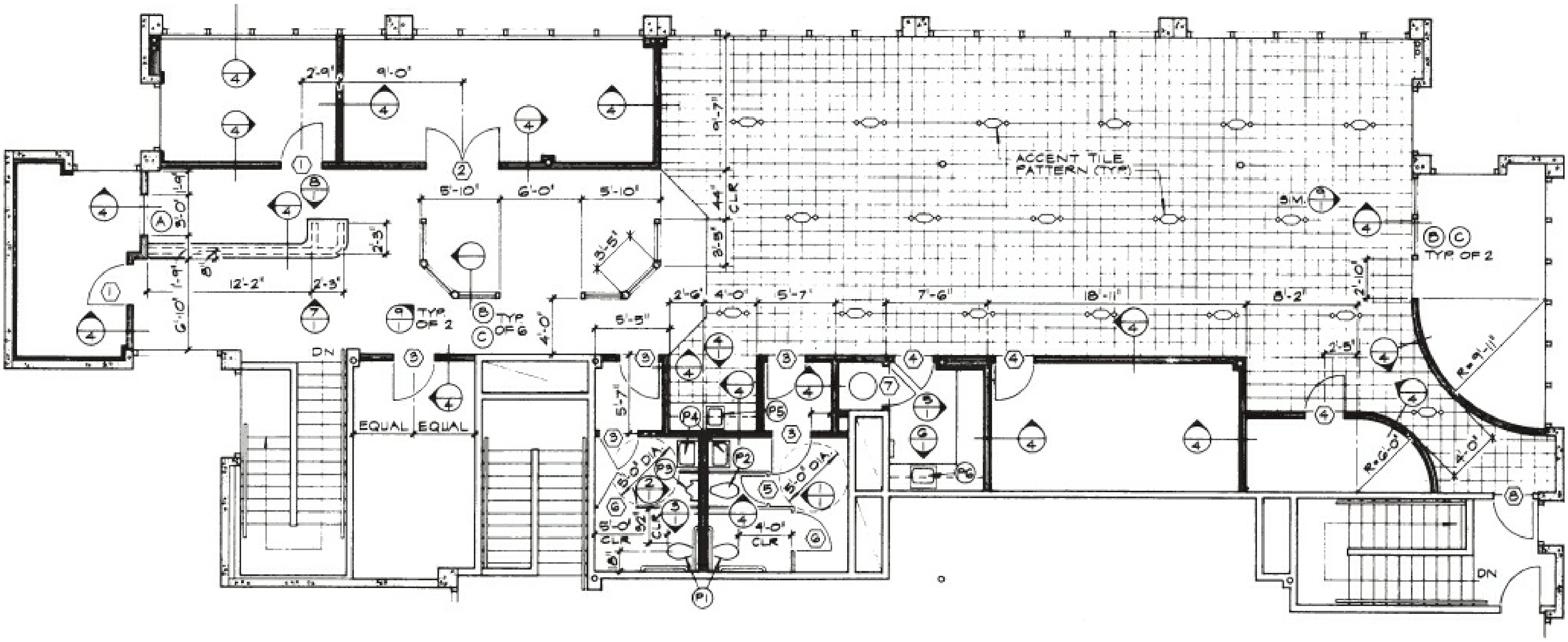


Figure 14.19 Wall shading and wall symbols.

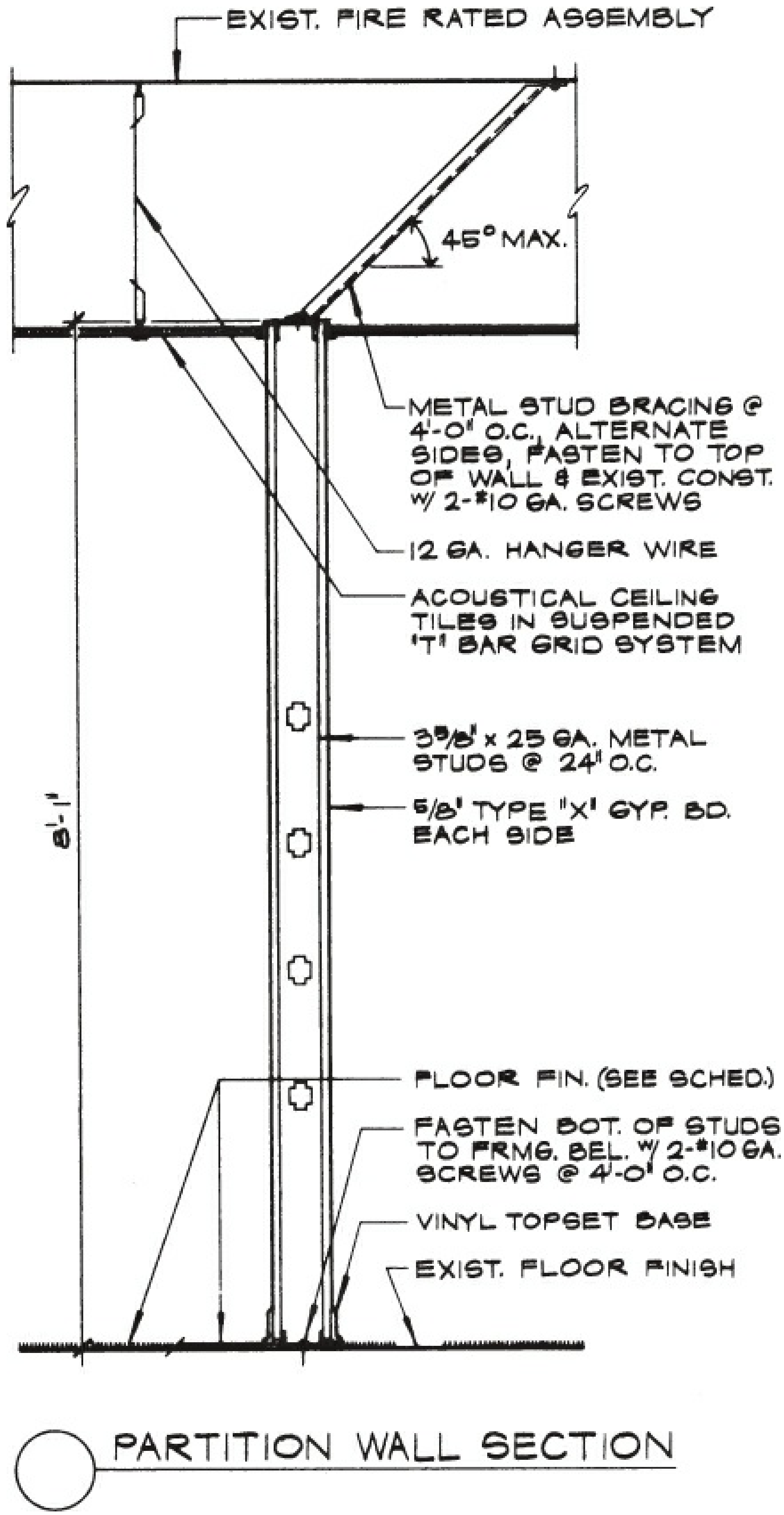


Figure 14.20 Non…bearing partition wall.

Figure 14.21 Stabilizing strut.

Figure 14.22 Wall framing—steel studs.

In cases where the ceiling is installed prior to the construction of the wall partitions, a similar method for stabilizing the wall, as shown in Figure 14.23, will be incorporated into the wall assembly. For the working drawings of this tenant improvement project, though, the wall section illustrated in Figure 14.20 will be used.

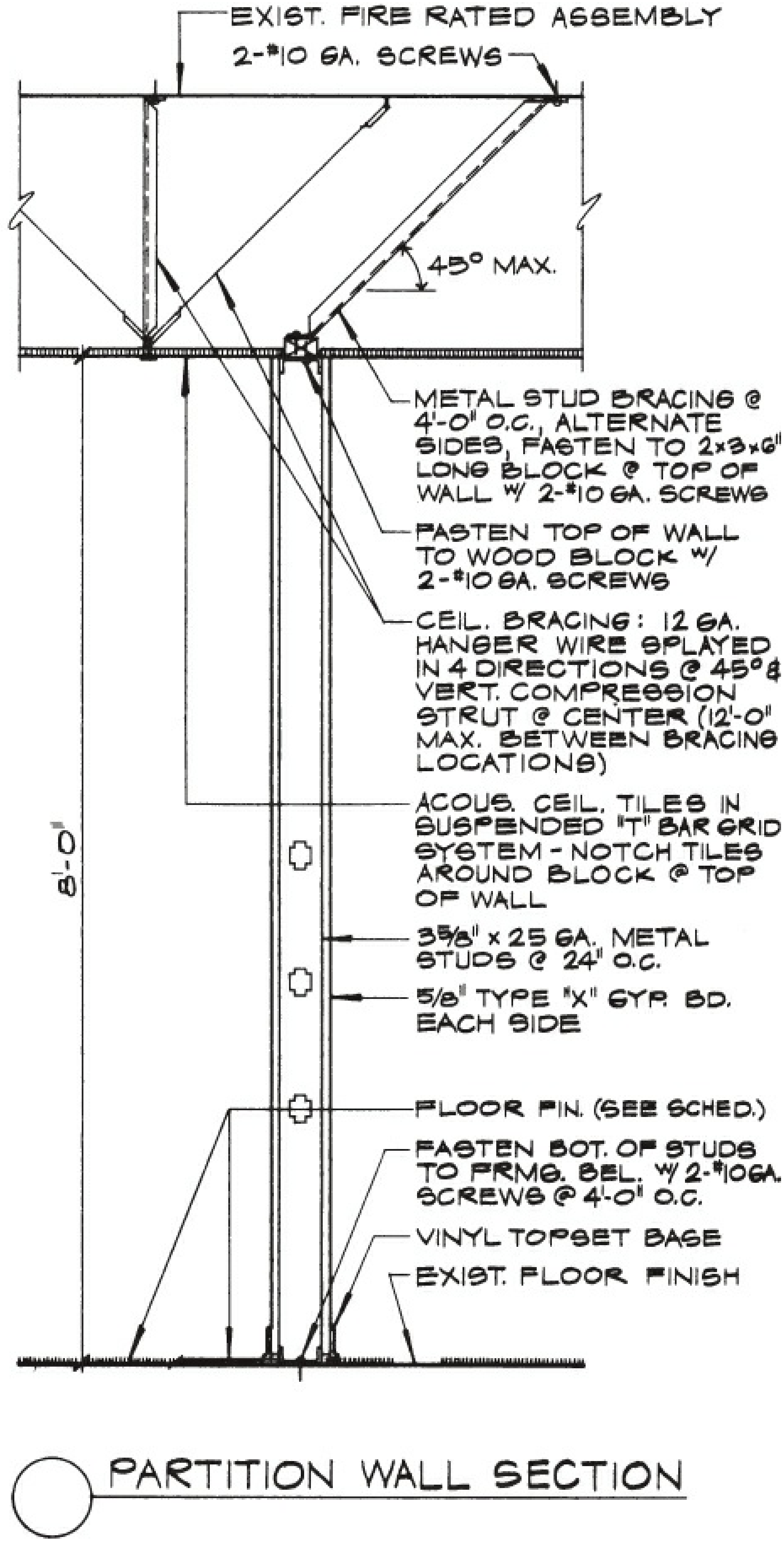


Figure 14.23 Non…bearing partition wall.

In tenant improvements projects, it often happens that the tenant or user will require additional soundproofing methods for the wall construction that separates specific areas. Figure 14.24 illustrates a separation wall terminating at the roof or floor system of an

existing structure. This method helps to reduce the transmission of sound from one area to another through the ceiling and plenum areas. A **plenum area**, a space used primarily for the location of mechanical ducts and equipment, is usually located above the finished ceiling. Figure 14.25 is a photograph of a small mechanical unit in the plenum area, which will distribute warm and cold air to the various tenant areas. It was decided that the studio would not have a finished ceiling so that the mechanical ducting for the heating, cooling, and ventilation could be exposed (shown later in the ceiling plan). In this case, the wall partitions will be detailed to extend to, and be secured at, the roof rafters (illustrated in Figure 14.26). Note that where the walls and rafters are not adjacent to each other, 2 × 4 blocking at 4′…0″ o.c. is installed to stabilize the wall laterally.

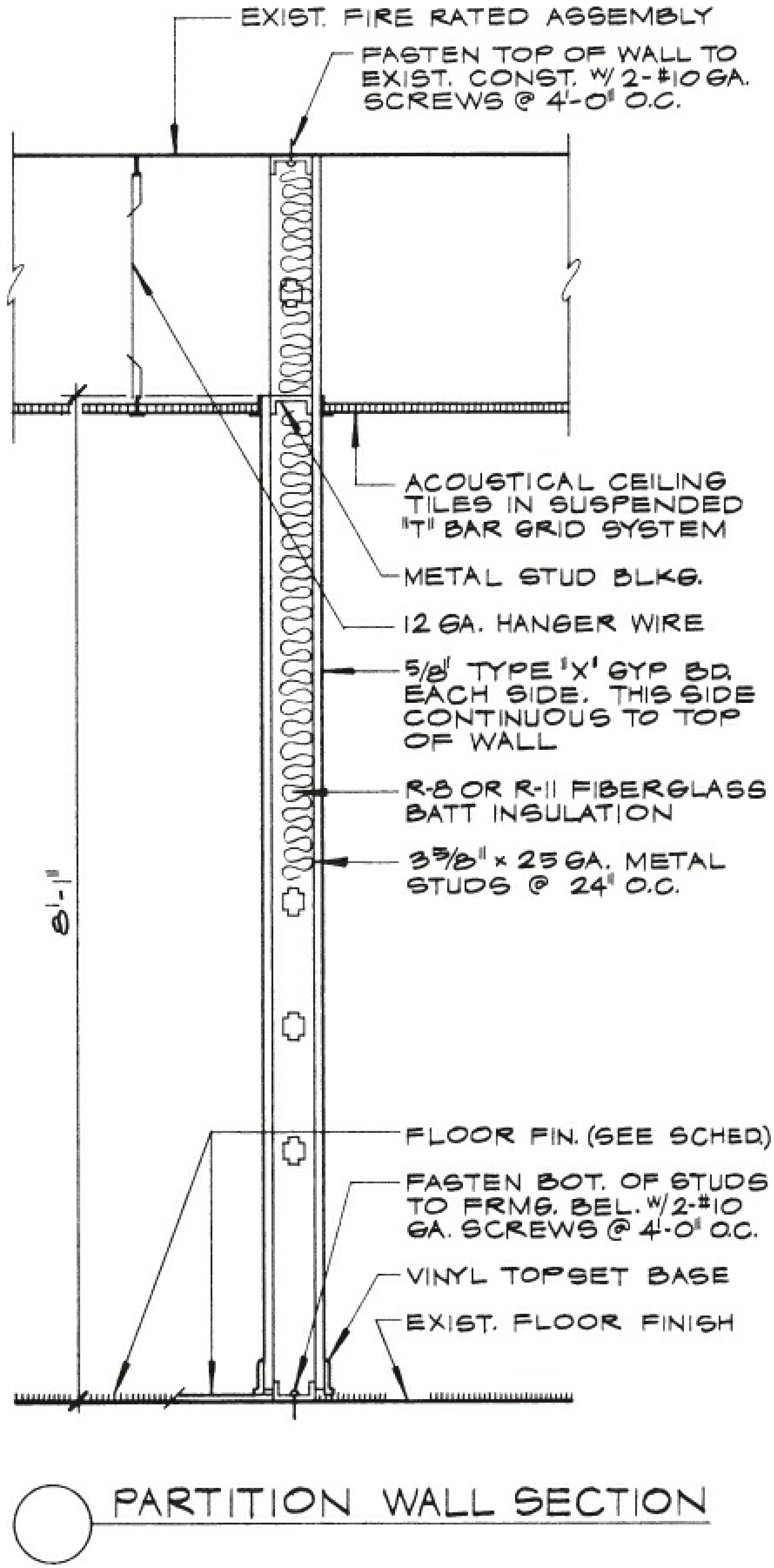


Figure 14.24 Sound deterrent partition wall.

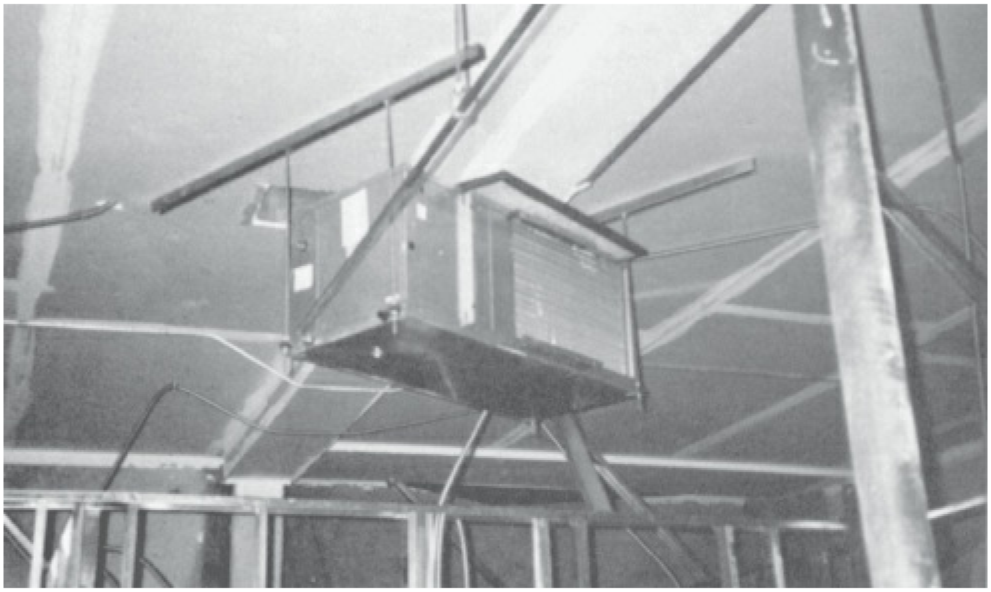


Figure 14.25 Mechanical unit.

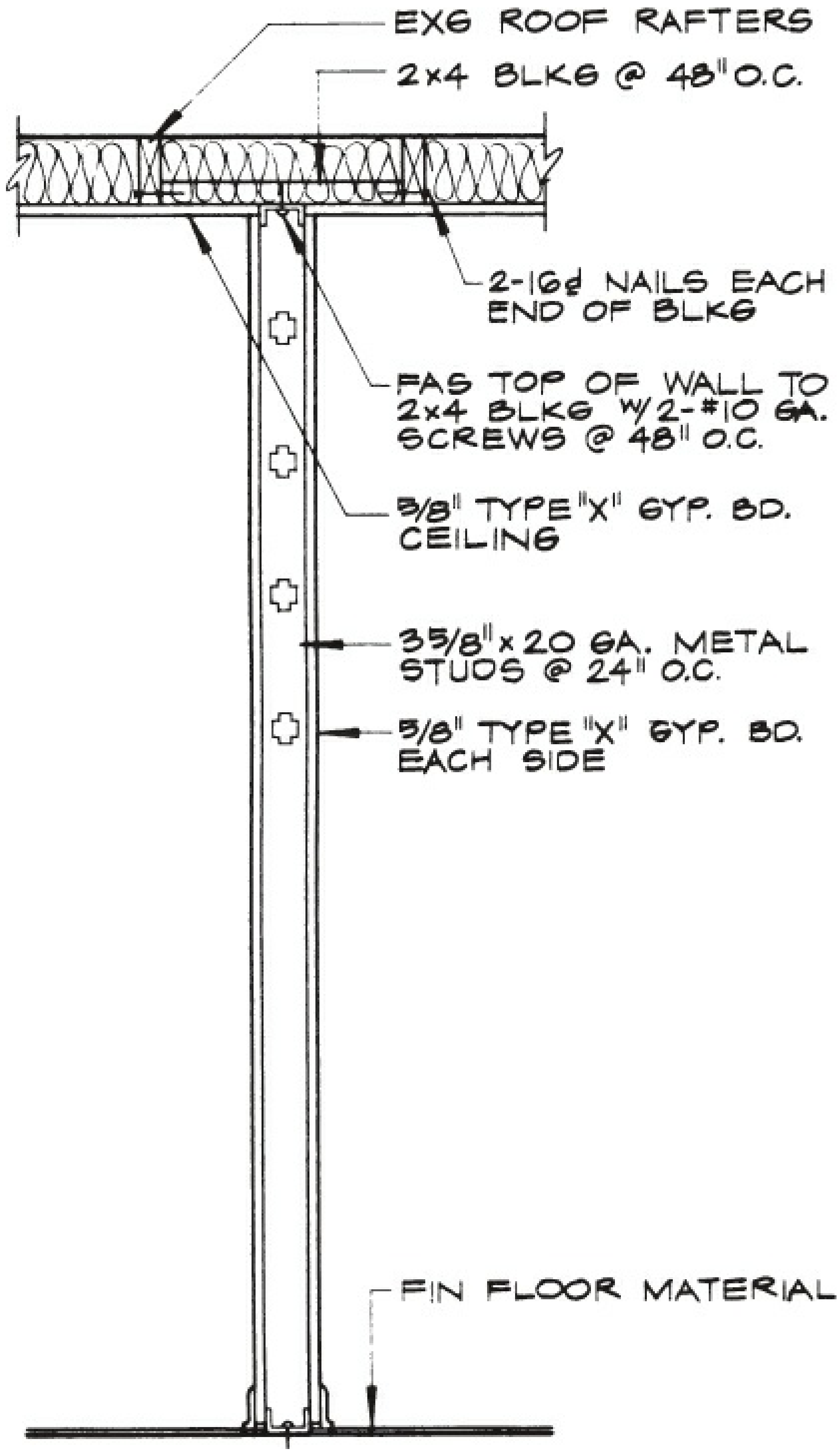


Figure 14.26 Wall section.

Often, as in this project, a mechanical equipment room is required to enclose a mechanical unit that will provide cooling, heating, and ventilating for a particular suite only. However, because of the noise produced by certain mechanical units, it is good practice to detail the walls of the mechanical room in such a way that the noise of the motors is minimized. A detail of one such wall is shown in Figure 14.27. Note that sound… absorbing board is installed on the inside of the mechanical room.

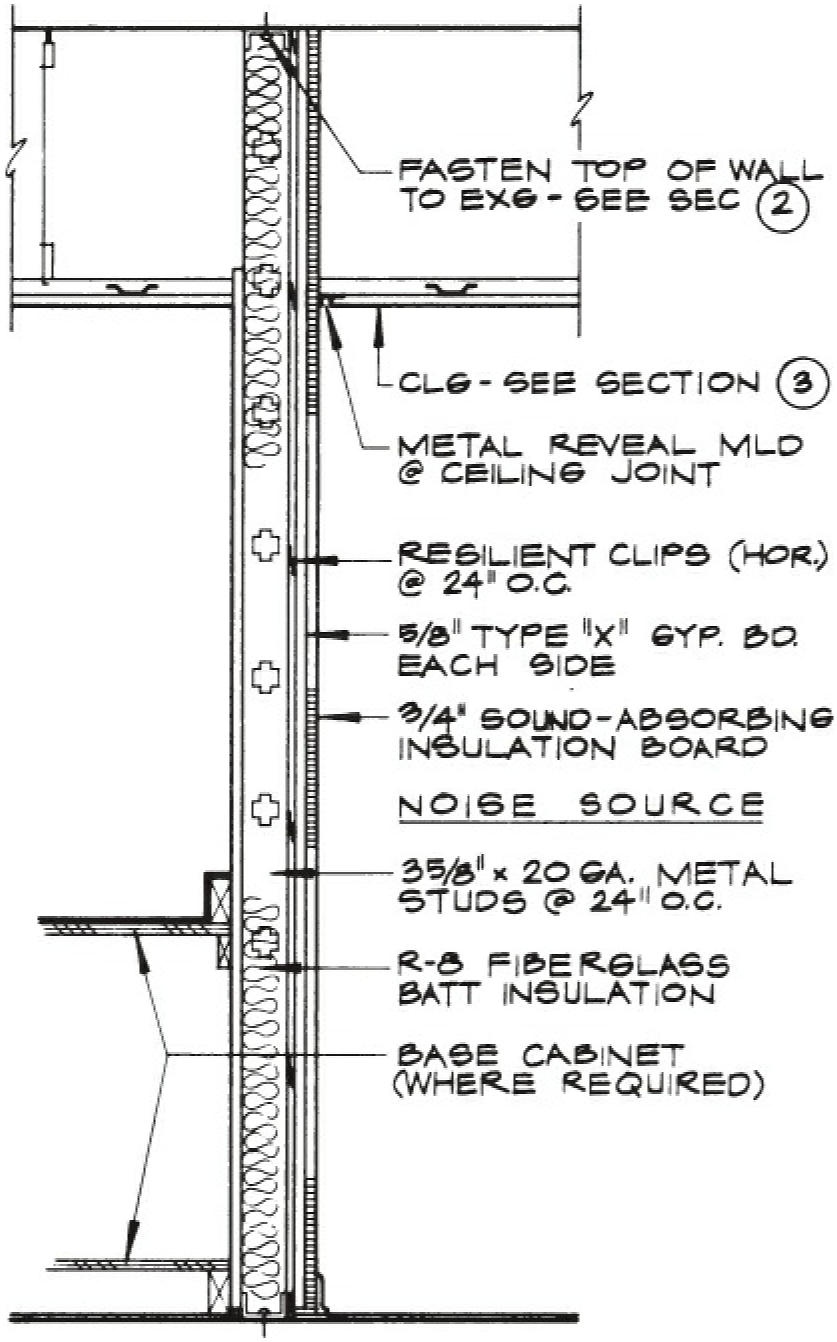


Figure 14.27 Sound wall section.

Existing Wall Furring

In projects where there are existing unfinished concrete or masonry walls, it will be desirable to furr out these walls in order to provide for electrical and telephone service and to develop a finished wall surface. **Furring** is adding a new inner wall to the main wall behind. Figure 14.28 illustrates a wall section where 1½″ metal furring studs have been attached to the existing unfinished concrete wall surface. In this detail, 5⁄8″…thick, type “X” gypsum wallboard has been selected for the interior wall finish.

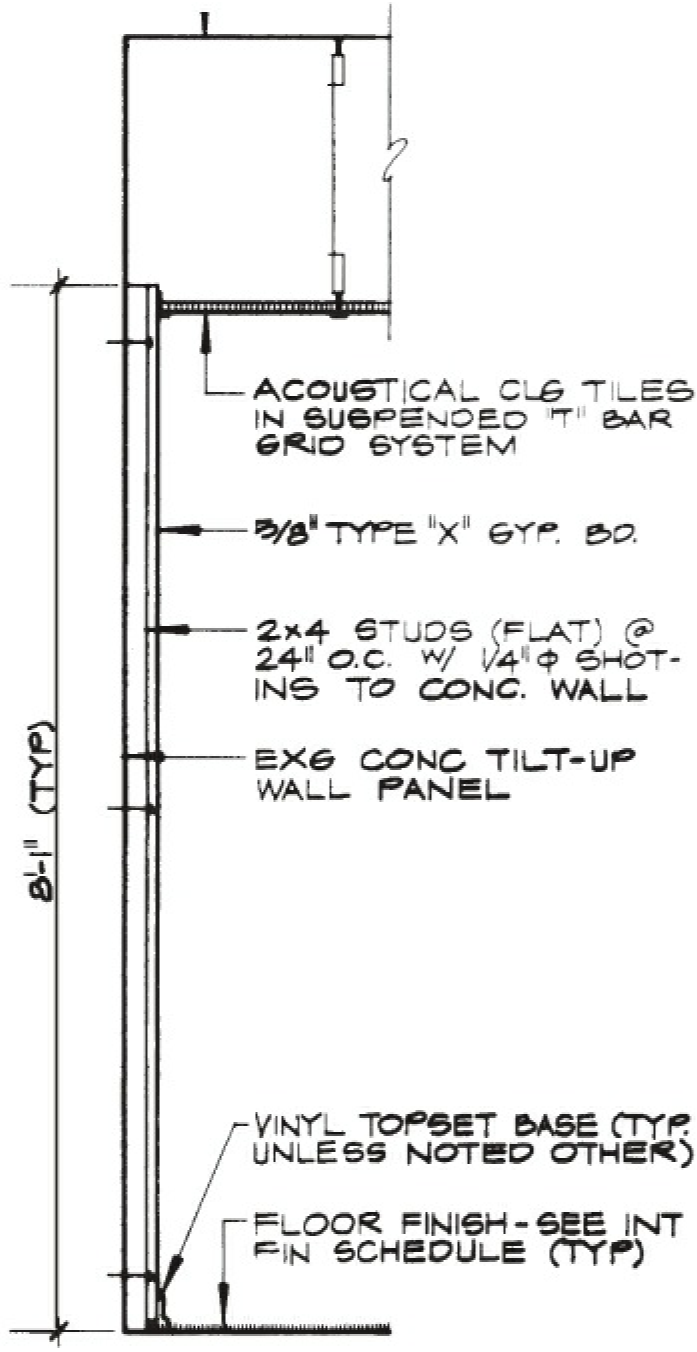


Figure 14.28 Existing wall furring.

Interior Glass Wall Partition

The tenant requested the use of glass wall partitioning to partially enclose the conference room area. The use of glass and metal frames for wall partitions still requires horizontal stability, as is necessary for other types of wall partitions. A section through this glass wall partition is shown in Figure 14.29. Note that all glazing will be tempered glass, as required by building codes and for the safety of the user.

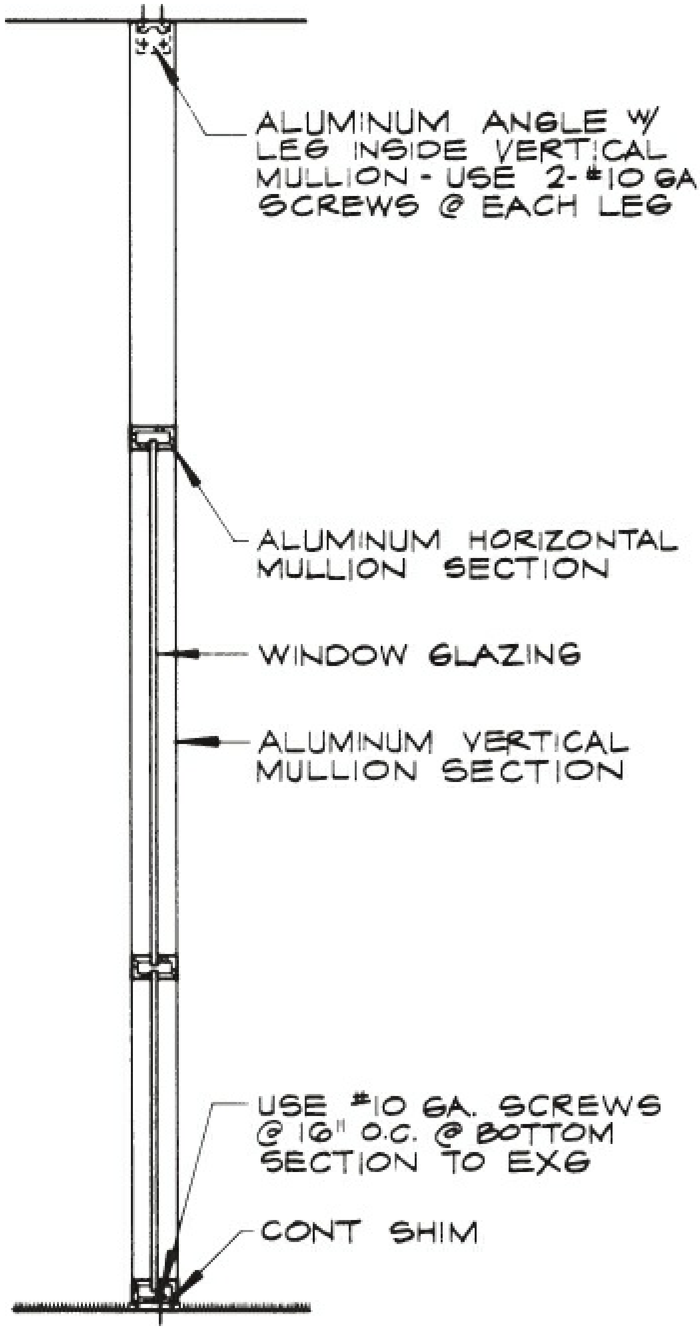


Figure 14.29 Glass wall partition.

Low Wall Partition

A low wall, called a **pony wall**, and a countertop are provided to separate the reception area from the secretarial area. This 42″…high wall will be attached to the adjacent wall and anchored at the base, as indicated in Figure 14.30. The stability of a low wall is most critical at the base; therefore, the method of assembly will be determined by the structural components of the existing structure.

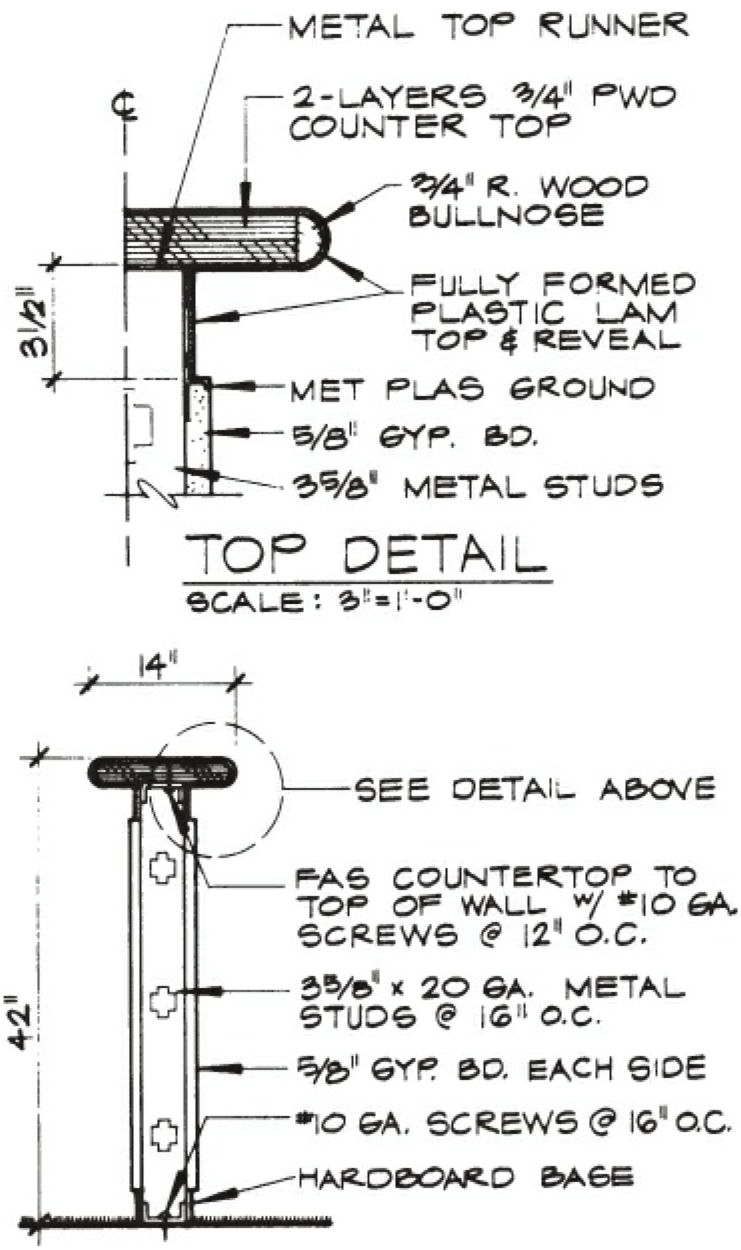


Figure 14.30 Low wall partition.

Interior Door and Window Assemblies

The door and window assemblies will be detailed to illustrate to the contractor the type of headers over the openings and the types of door and window frames that have been selected. The stabilization at the tops of these assemblies will be identical or similar to the stabilization for the wall partitions. Figure 14.31 depicts the use of a metal header over the door opening, incorporating the use of a hollow metal door frame. The manufacturer and type of metal door frame will be called out on the door schedule.

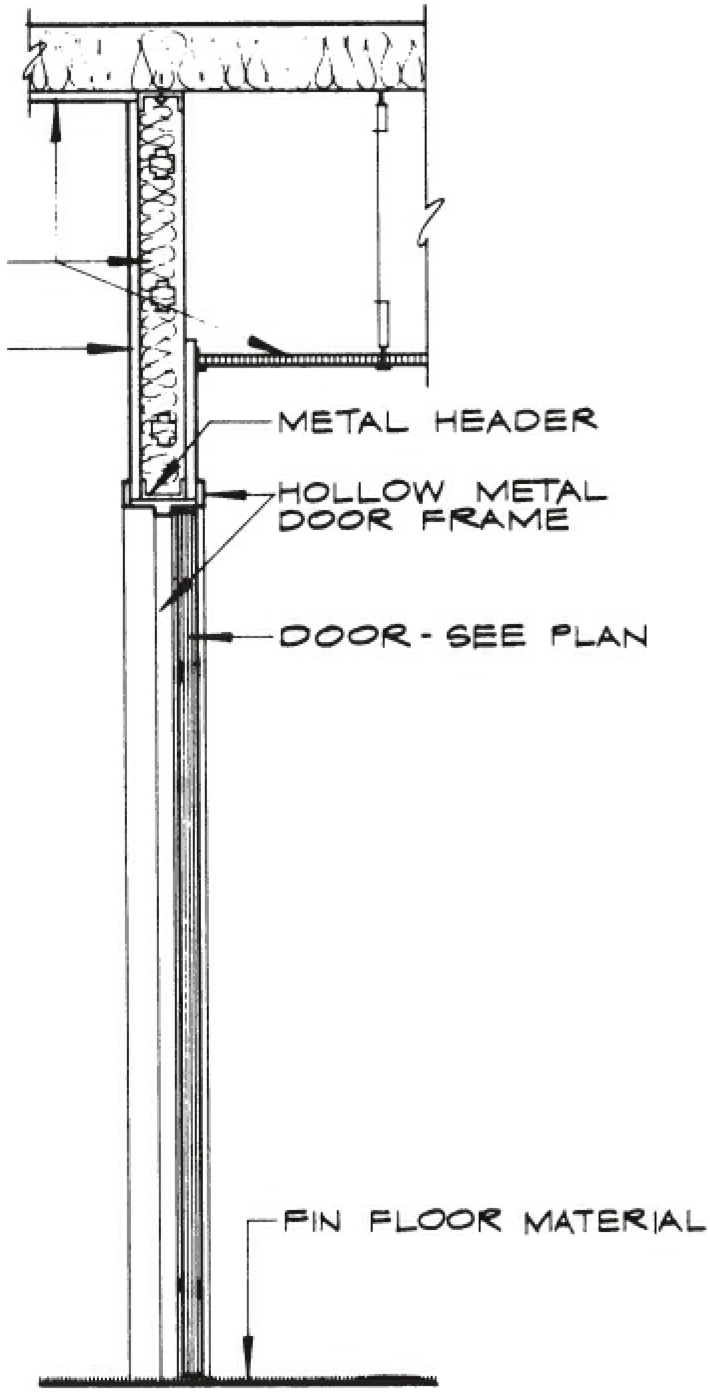
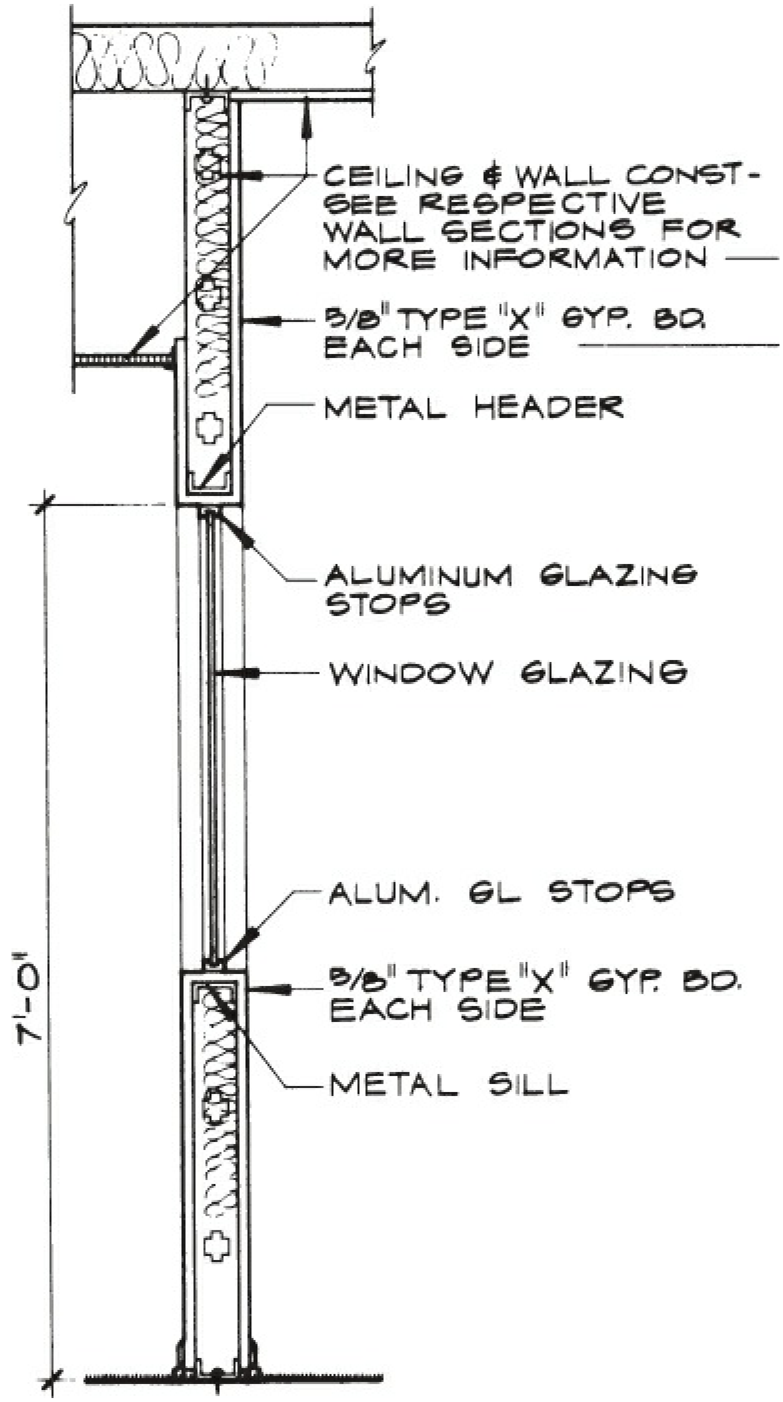


Figure 14.31 Interior door—wall section.

Wall partitions that incorporate windows will be detailed to delineate the type of header, window frame material, and the construction of the wall portion in the assembly. The interior window located between office 3 and the secretarial area is detailed in a wall section illustrated in Figure 14.32



[Figure 14.32](#) Interior window and wall section.

The sizes, thickness, and types of doors and windows will be stipulated on the door and window schedules (illustrated later in this chapter). It should be noted that upon completion of the detailing for the various partition walls and door and window assemblies, these details will be referenced on the floor plan, using circles and numbers as a means of identification.

Electrical and Communication Plan

After the locations of partition walls, doors, windows, and furniture have been established, the architect or space planner, consulting with the tenant, may now proceed to develop an electrical and communication plan. The electrical portion of this plan will consist of the location of convenient electrical outlets installed approximately 12″ above

the floor, unless noted otherwise by a dimension at the outlet. The communication installation will comprise telephone jacks, a connection for the facsimile (fax) equipment, and a rough…in electrical service for the tenant's computer hardware. An electrical and communication plan prepared for this tenant of Building B is illustrated in Figure 14.33. It should be noted that, on some projects, the electrical and communication design may be so complex that separate plans must be provided and delineated for clarity.

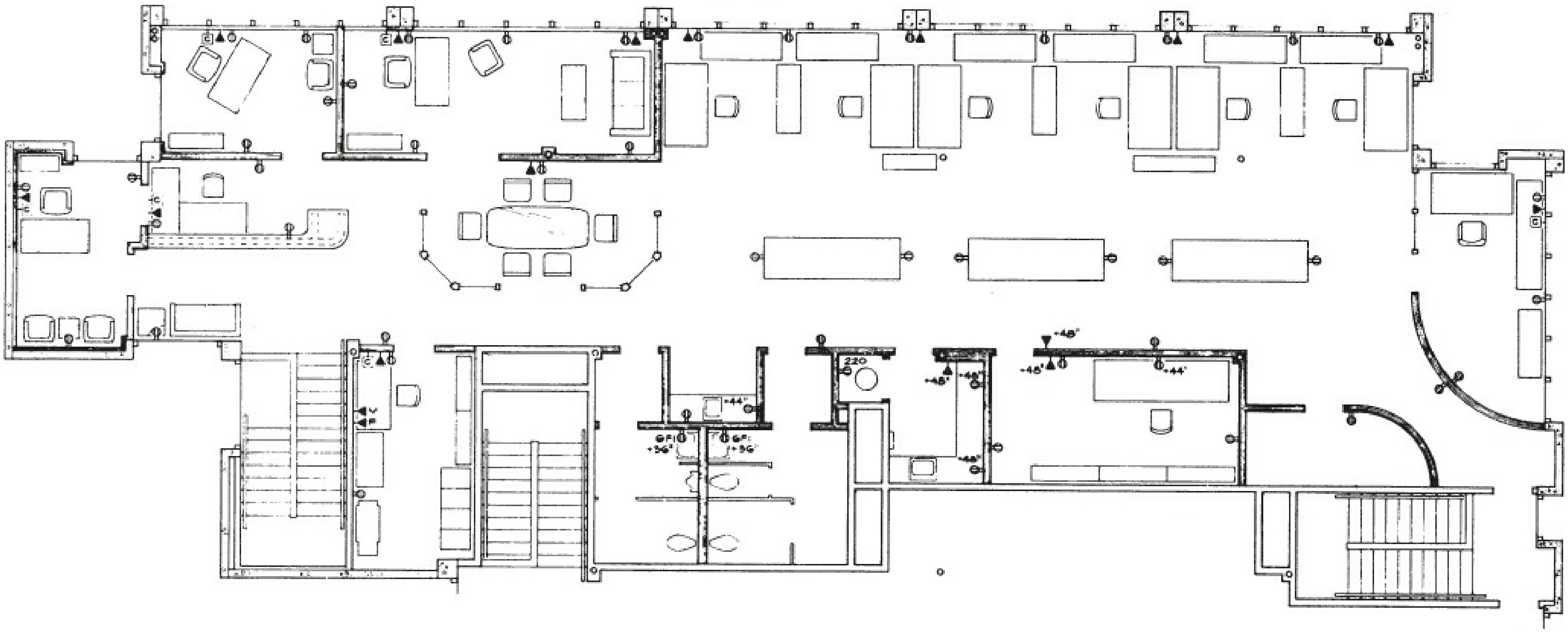


Figure 14.33 Electrical and communication plan.

Ceiling Plan

A ceiling plan that includes the height of the ceiling will be drawn to delineate the following: location of ceiling lighting fixtures, symbolized for reference to the lighting fixture schedule; suspended ceiling design; the type of system to be specified; and other types of ceiling finishes. Switch locations for the various lighting fixtures will also be shown on this plan.

For this project, it was decided that a suspended ceiling system with recessed lighting fixtures would be specified for offices 1, 2, and 3. As mentioned earlier and detailed in Figure 14.20, the walls will be installed first, thus providing the designer with greater design flexibility for the layout of the suspended ceiling grid system and the location of lighting fixtures. To illustrate the design flexibility of this wall installation method, the ceiling plan shown in Figure 14.34 shows the suspended ceiling and lighting fixtures to be symmetrical within the offices, thereby creating a more pleasing ceiling design and lighting fixture location. Mechanical ducts for heating and cooling these offices will be installed and concealed above the suspended ceiling system. Note that the walls are drawn with two lines only, as there are no wall openings at the ceiling level.

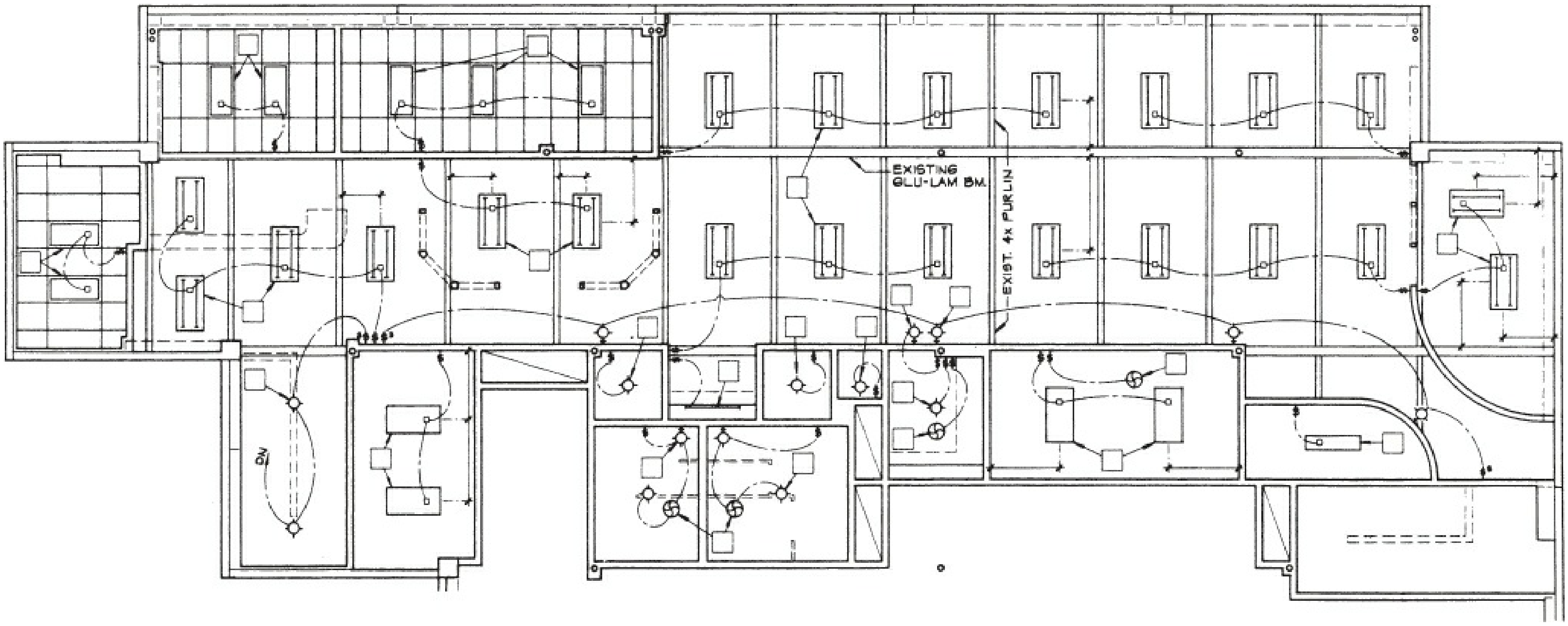


Figure 14.34 Ceiling plan.

At the request of the tenant, the remaining rooms and task areas will not have a suspended ceiling system; rather, gypsum wallboard will be attached directly to the existing structural roof members, with the gypsum board being finished and painted. For wall reference, see Figure 14.26.

The ceiling finish and location selected allow the mechanical ducts to be exposed and painted. These round mechanical ducts, when exposed and painted, will provide a decor compatible with the artwork and graphic design produced by this tenant. On the ceiling plan, as depicted in Figure 18.28, the designer has shown the desired location of the mechanical ducts and supply registers. The consulting mechanical engineer will specify, in the mechanical drawings, the sizes of the ducts, type of supply registers, and type of equipment to be used.

As previously mentioned, the lighting fixtures will be given a reference symbol that will also be on the electrical fixture schedule. That schedule will provide a description of the fixtures, including the manufacturer and model numbers. Designation of the finished ceiling material may be shown on the ceiling plan for convenience; in any case, these finishes will be designated on the interior finish schedule. Electrical and interior finish schedules, as well as other schedules, are discussed and illustrated later in this chapter.

Interior Elevations and Schedules

Interior elevations and schedules are usually included in the construction documents but were eliminated here, because their creation would follow the same procedures as those found in Chapters 1 and 2. They are also shown in their entirety in the construction documents evolution discussion to follow in this chapter.

WORKING DRAWINGS

The following paragraphs describe the working drawings at various stages of the development for the tenant improvement project in Building B.

Floor Plan

Stage I (Figure 14.35). At a larger scale, the draftsperson lightly blocked out all the existing exterior and interior walls for the area identified as Suite 201. This drawing included existing windows, structural columns, roof drain leaders, stairwells, and mechanical shafts. Also included in this first…stage drawing was the initial site plan layout.

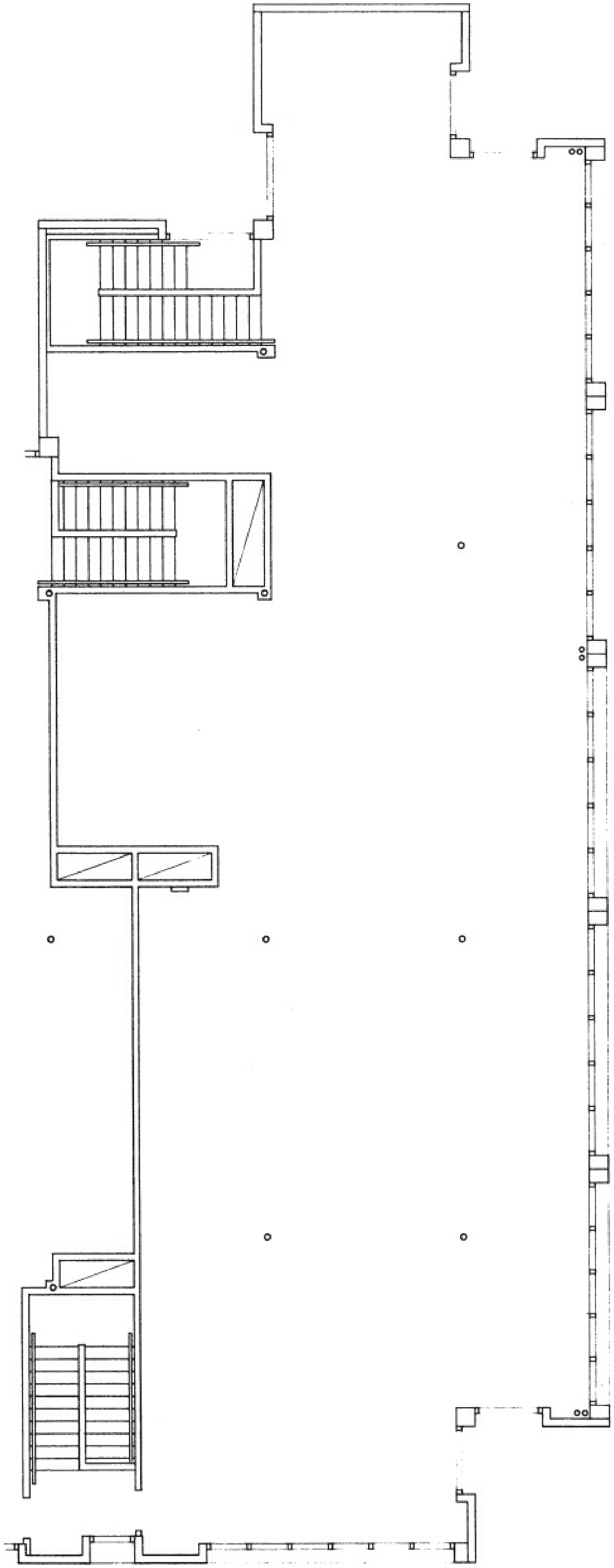
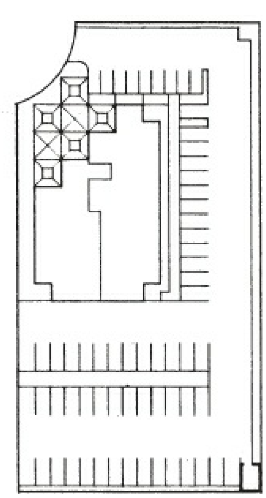



Figure 14.35 Stage I: Floor plan.

Stage II (Figure 14.36). After the required room locations and their sizes were determined from the schematic drawings, wall locations were established with their accompanying dimension lines only. All the existing and new walls were darkened for future clarity. Doors and their swing directions were added, along with wheelchair clearances in the men's and women's restrooms. The various interior elevations were lightly blocked out, and the site plan—illustrating the exact location of Suite 201 in this existing structure—was finalized.

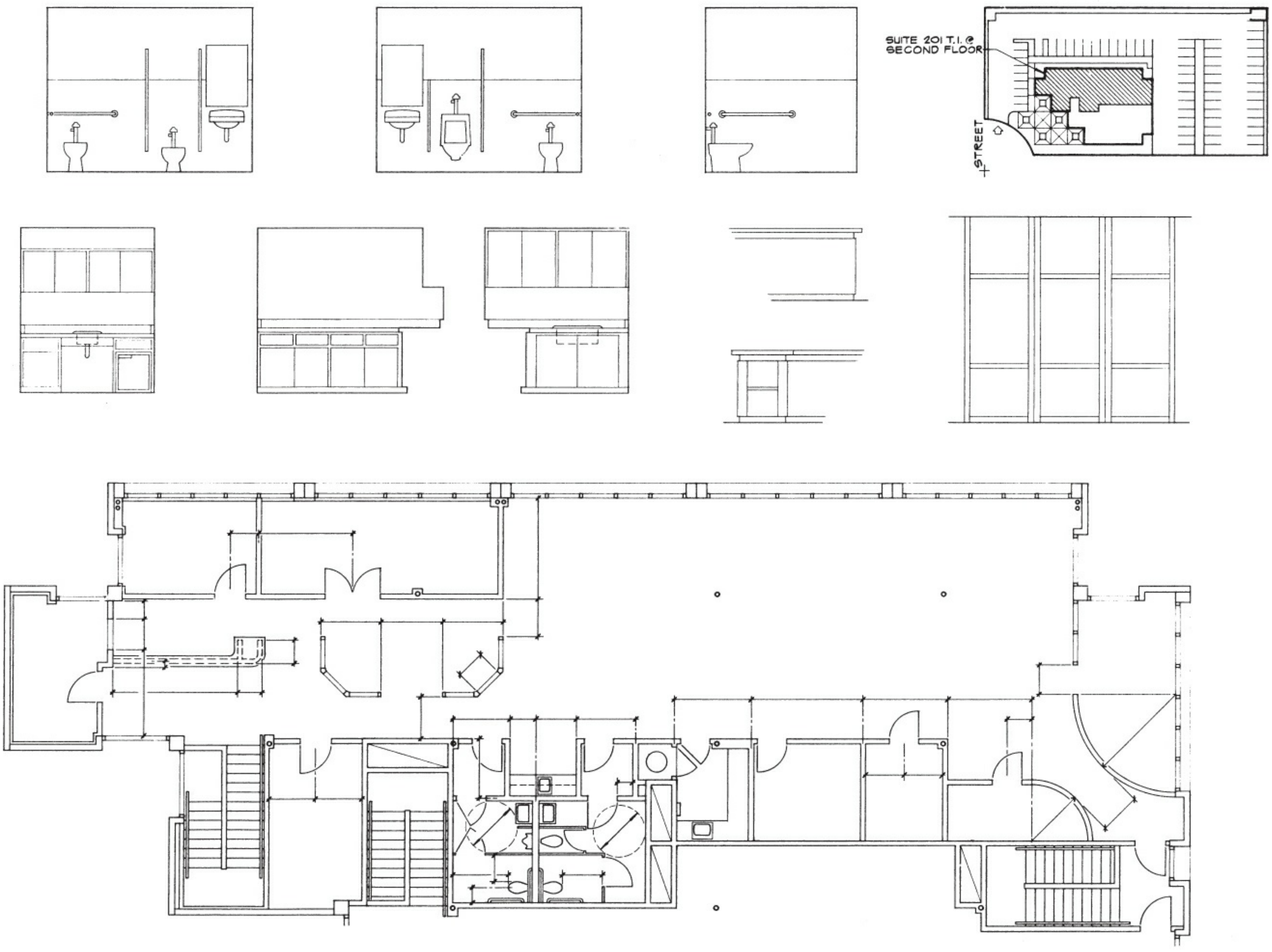
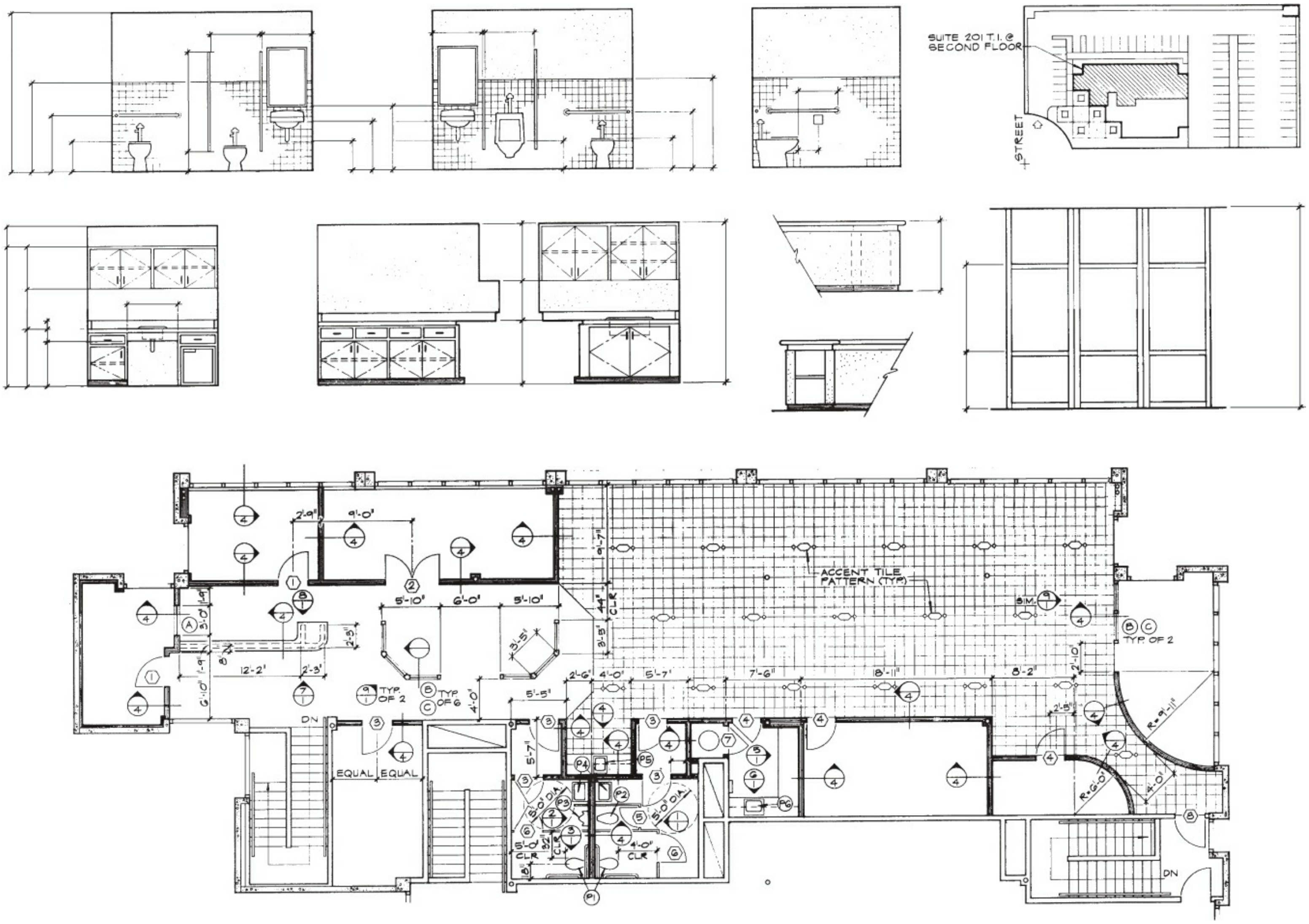


Figure 14.36 Stage II: Floor plan.

Stage III (Figure 14.37). At this stage of the floor plan, all the wall partitions were dimensioned, and the new walls were darkened solid to distinguish them from the existing walls. Note that in the reference room, next to the darkroom, a wall was eliminated to provide more space for equipment. See Stage II. Door symbols and their numbers have been incorporated, along with plumbing fixture symbols and their accompanying designations. Also included are reference bubbles for the various wall sections with their designated numbers and locations. Interior elevation reference symbols have been added and will later be located on their respective wall elevations.

Symbols for glass sizes are shown at the various glass partition locations. At this stage of the floor plan, the specified tile floor and accent pattern locations are delineated in the studio area. The lines on the interior elevations are darkened and profiled for clarity with material designations, cabinet door swings, incorporating the various dimension lines.



[Figure 14.37](#) Stage III: Floor plan.

Stage IV ([Figure 14.38](#)). This is the final stage for the floor plan, interior elevations, and site plan. A wall legend is included on the floor plan, illustrating the various wall conditions. All final notes and room designations have been lettered, and the designated wall detail numbers have been placed in the various reference bubbles. Lettering and dimensioning on the interior elevations are finalized at this stage, along with the titling and reference numbering for various wall elevations as they relate to the floor plan. Final notes are lettered on the site plan, and titles are provided for the site plan and floor plan. The scales used for various drawings are now lettered and located below the drawing titles.

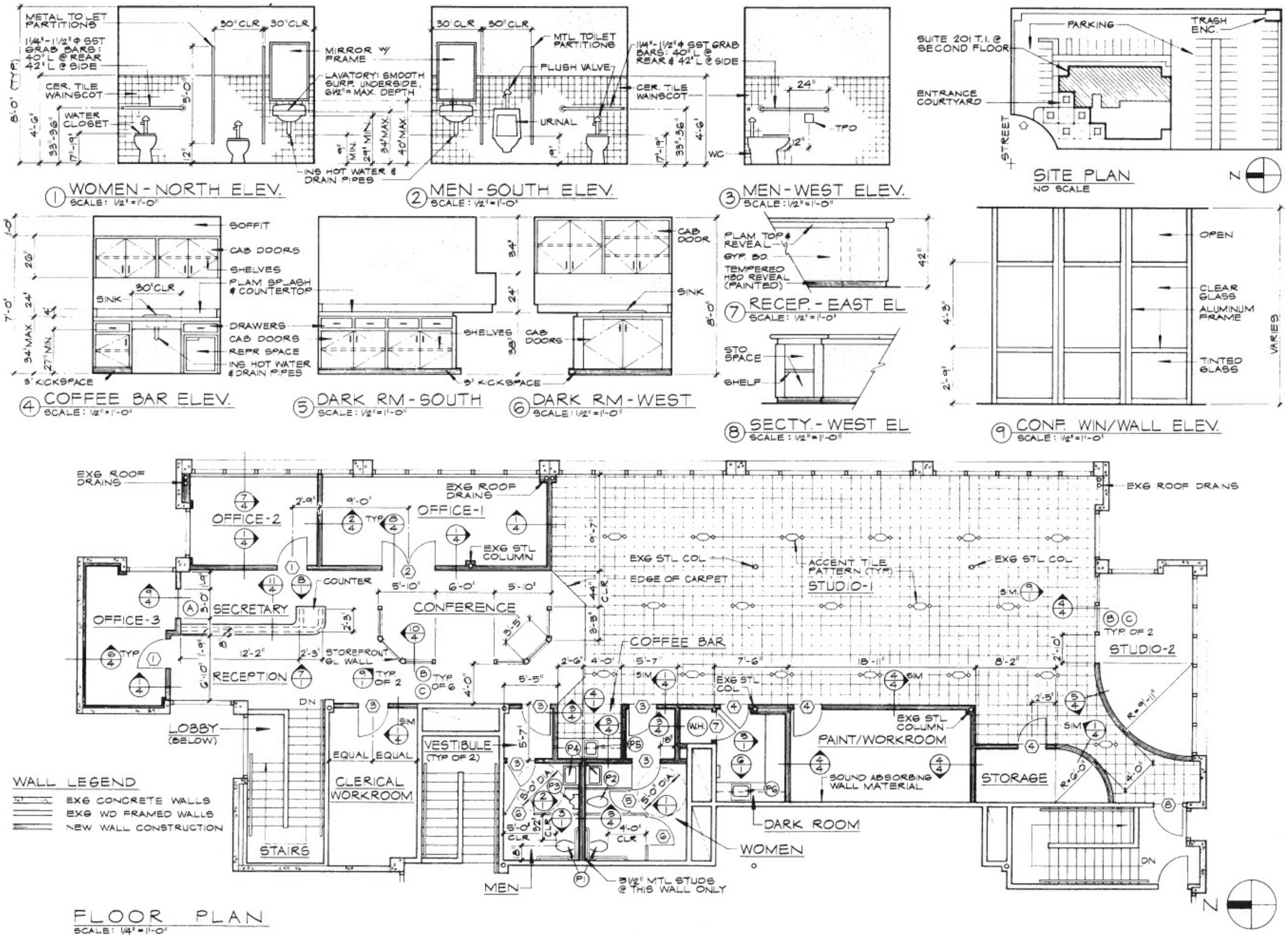
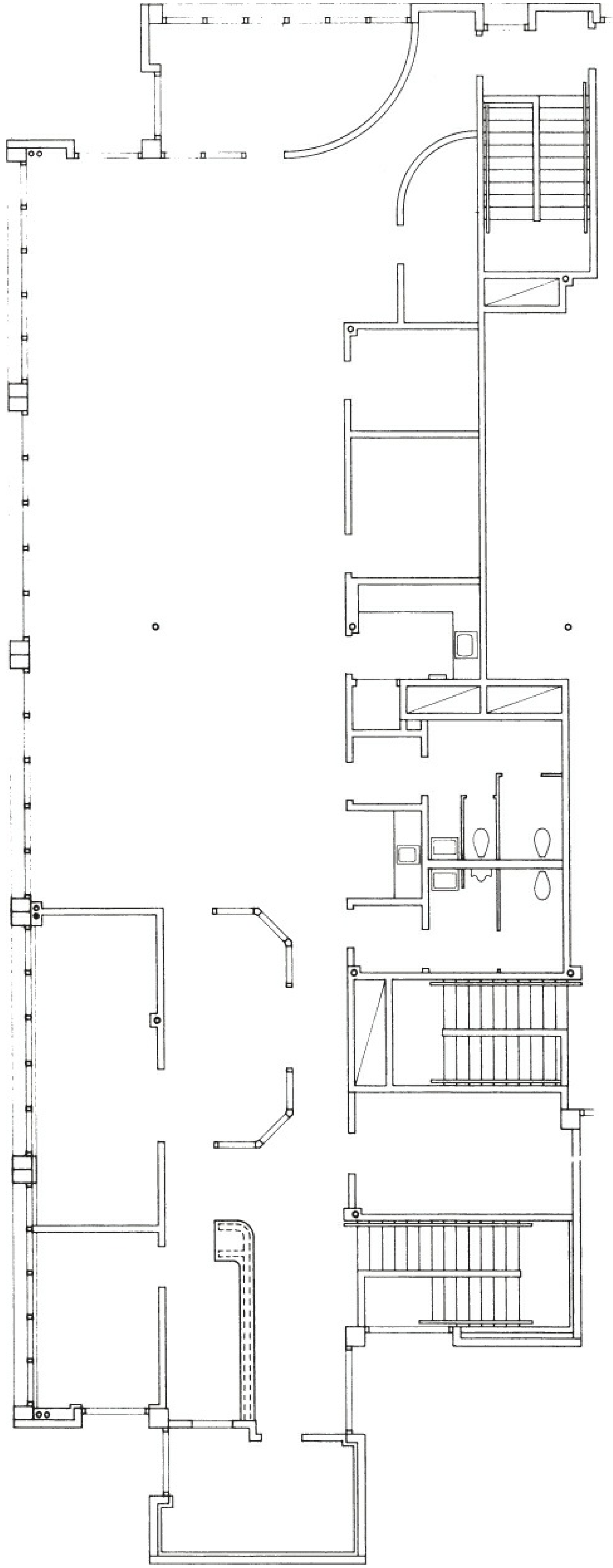


Figure 14.38 Stage IV: Floor plan.

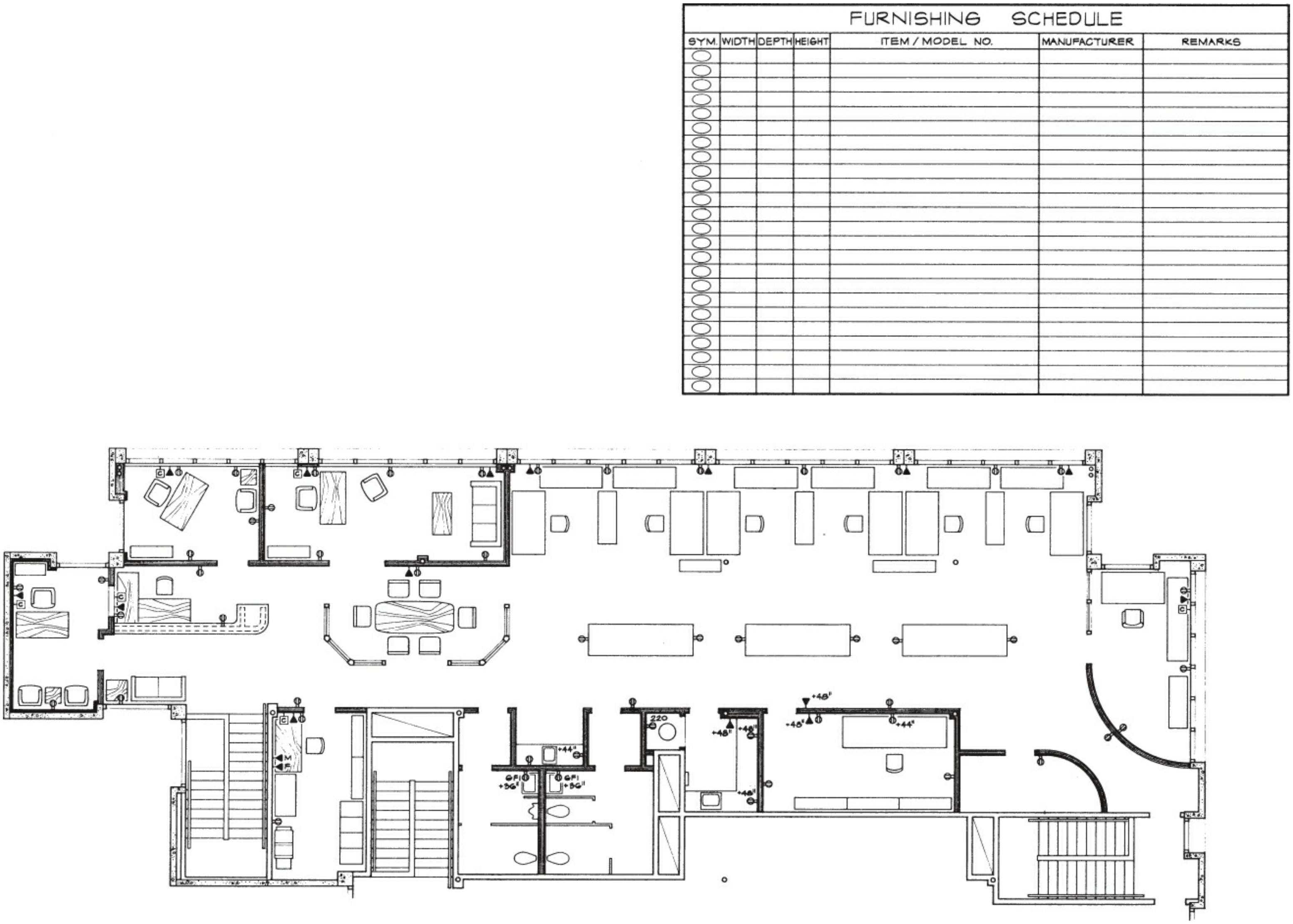
Furnishing, Electrical, and Communication Plan

Stage I (Figure 14.39). The initial step for this stage was to draft a floor plan incorporating the exterior walls, interior partitions, plumbing fixtures, and cabinet locations. Note that door swings and their directions are not delineated. In many offices, this stage may be a reproduction of an earlier floor…plan stage, or may be XREFed.



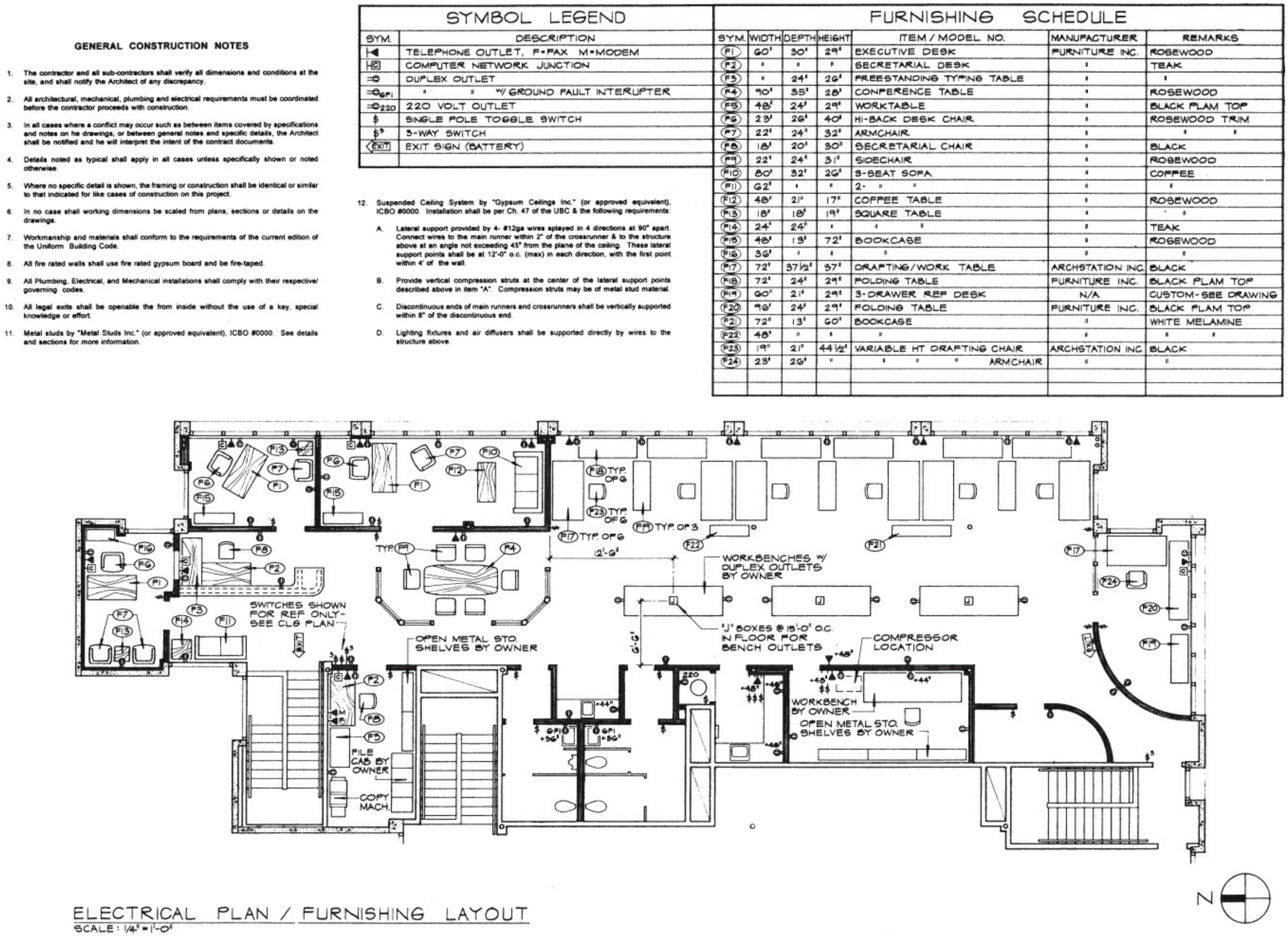
[Figure 14.39](#) Stage I: Electrical plan—furnishing layout.

Stage II ([Figure 14.40](#)). The first concern at this stage was to lay out all the required furniture necessary for the function of the tenant's business. With the furniture locations established, electrical, telephone, and facsimile outlets can now be located as required by the tenant. Also included at this stage is a furnishing schedule, which may be completed at a later stage or may be XREFed.



[Figure 14.40](#) Stage II: Electrical plan—furnishing layout.

Stage III ([Figure 14.41](#)). To complete the electrical plan and furnishing layout, symbols for furniture identification are located accordingly and lettered for reference on the furnishing schedule. Final notes are provided for electrical outlet locations, as well as for the various furnishing items that will be supplied by the tenant. The furnishing schedule is now complete, as it provides symbol designations, sizes, and manufacturers' equipment designations. A legend is drawn and completed for the identification of electrical symbols, such as for the type of outlets and switches. General construction notes covering the various construction phases are included with this drawing.



[Figure 14.41](#) Stage III: Electrical plan—furnishing layout.

Ceiling Plan

Stage I ([Figure 14.42](#)). At this stage, the exterior and interior walls are lightly blocked out, illustrating the walls as they appear at the ceiling level.

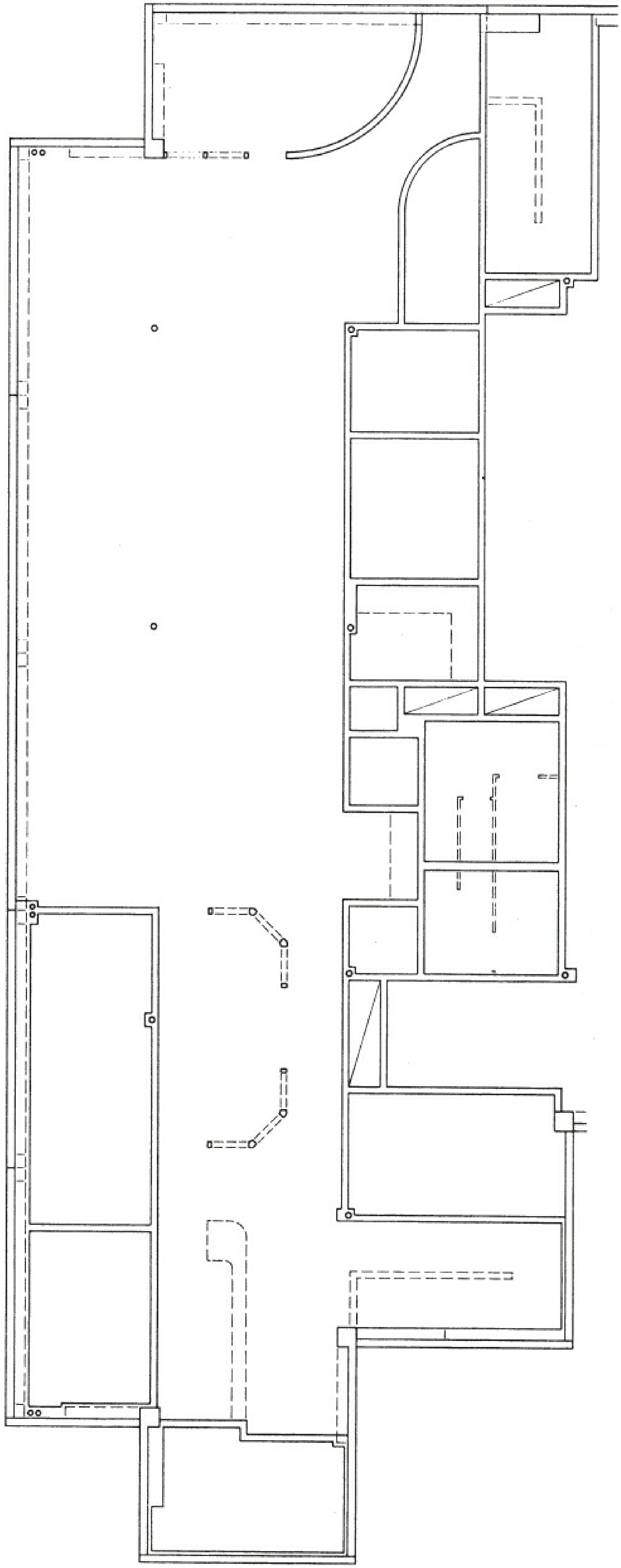


Figure 14.42 Stage I: Ceiling plan.

Stage II (Figure 14.43). The exterior and interior walls are darkened to provide greater clarity at this stage. The three office areas that will have a suspended ceiling system have been delineated to illustrate the grid pattern, lighting fixture location, and their identification symbols. Also shown are the light switches for the various lighting fixtures. All the surface…mounted lighting fixtures, exhaust fans, and accompanying switches for the various fixtures are completed in this stage. Fixture symbols are now located for the identification of the various electrical fixtures. (The symbols will be completed at a later stage.) Finally, schedules for the doors, electrical fixtures, plumbing fixtures, and room finishes are drawn in preparation for listing the various sizes, materials, and manufacturers' identification numbers.

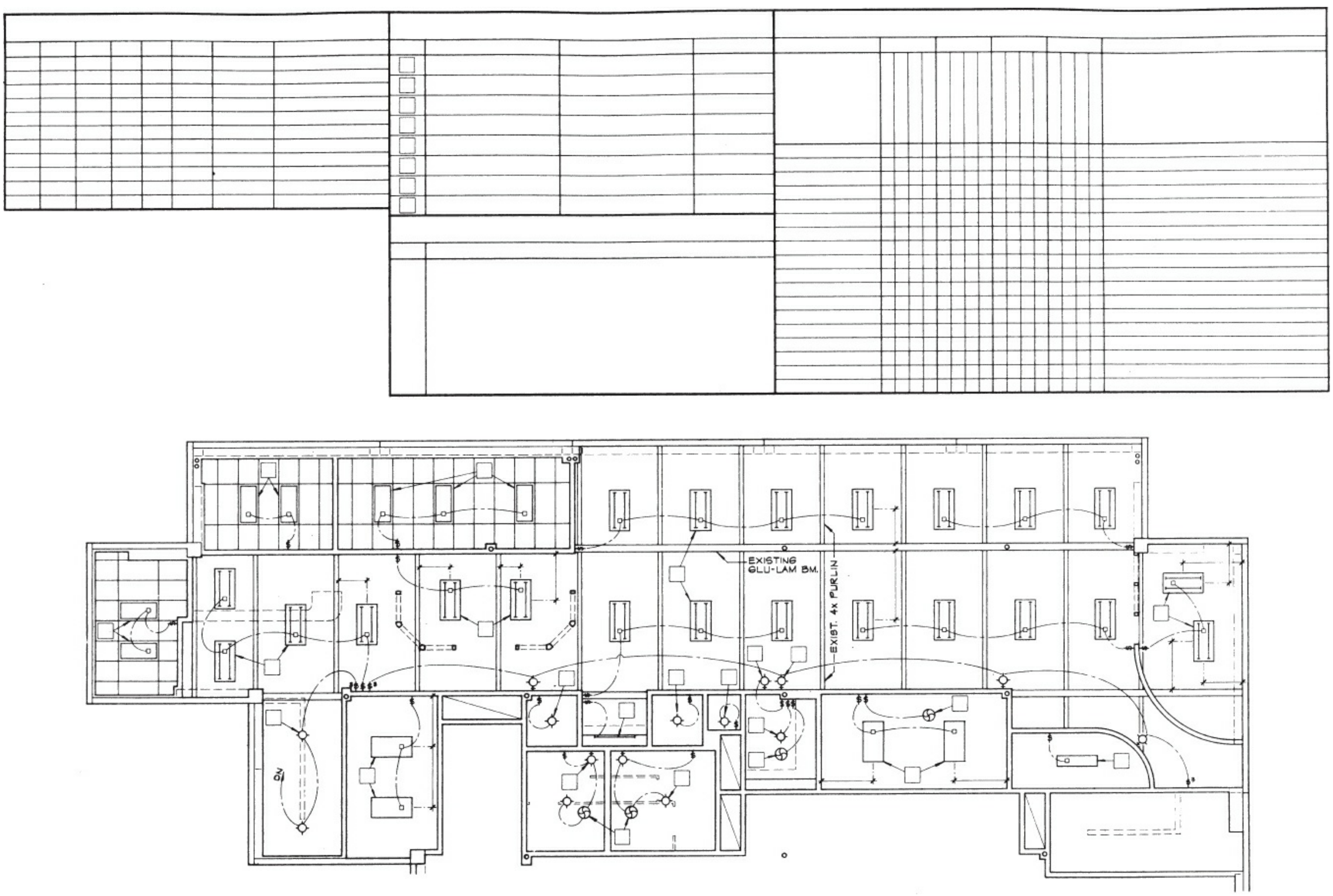


Figure 14.43 Stage II: Ceiling plan.

Stage III (Figure 14.44). The final stage of the ceiling plan includes lettering all the lighting fixture symbols and locating the heating supply air ducts and diffusers. Dimensioning of some of the various lighting fixtures has now been completed, as have the final notes and the title of the drawing. The scale designation and ceiling heights are called out.

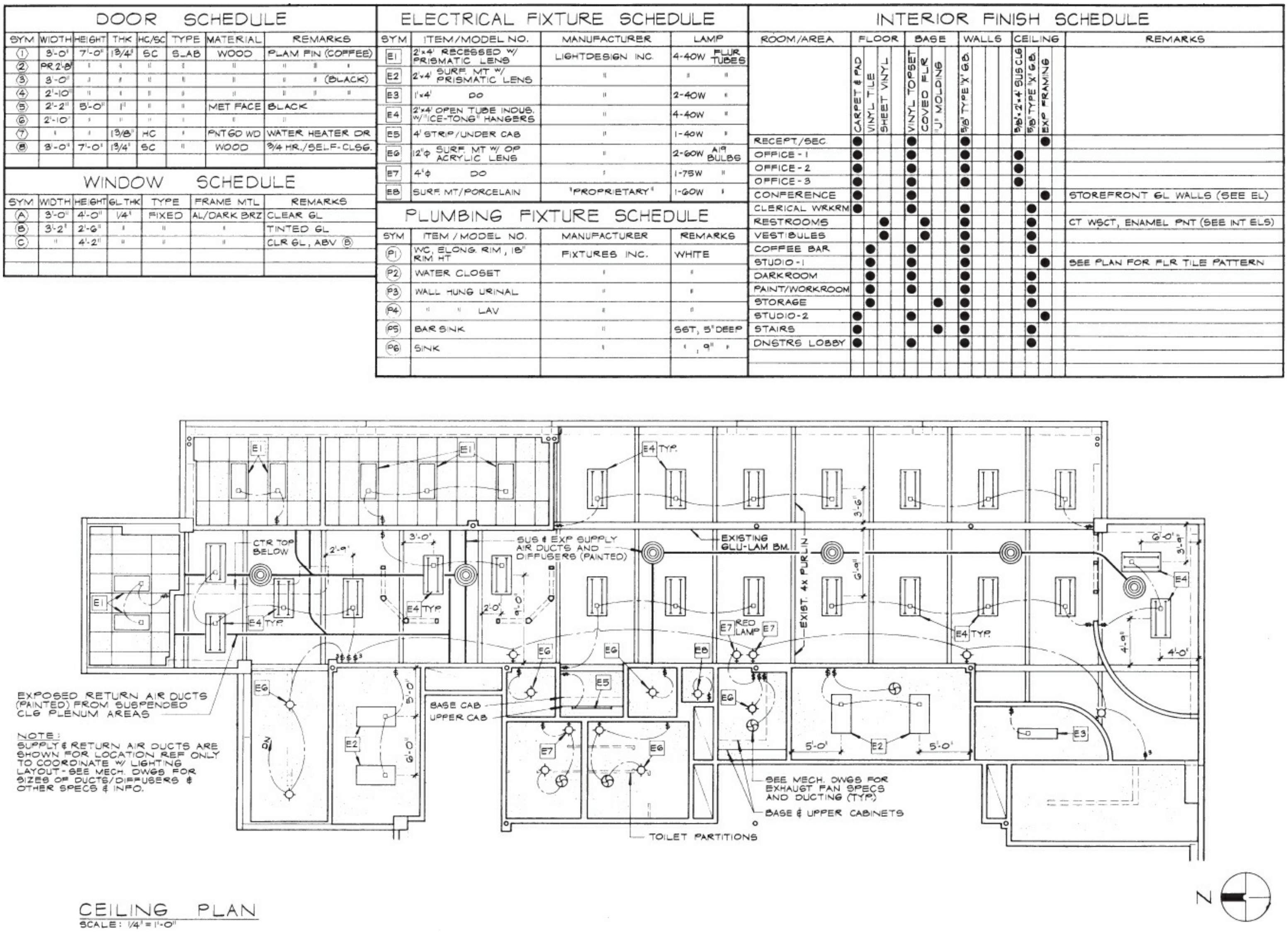


Figure 14.44 Stage III: Ceiling plan.

The various schedules that were blocked out in Stage II are now completed, providing all necessary information and symbol identification.

Tenant Improvement and Computers

Presently, most tenant improvement work is done on AutoCAD. This is because the buildings being used by tenants have already been built, in most cases using designs drafted in AutoCAD. We are in a transitional period, and of the structures currently being built, only a small portion of them are designed and drawn in BIM. Thus, the drawings must still be verified in size and shape and drawn over. A multistory building occupancy might be drawn in BIM because of the complexity of rerouting plumbing, air conditioning, heating, and so on.

Key Terms

as built

furring

improvement

internal planning

non…load…bearing wall

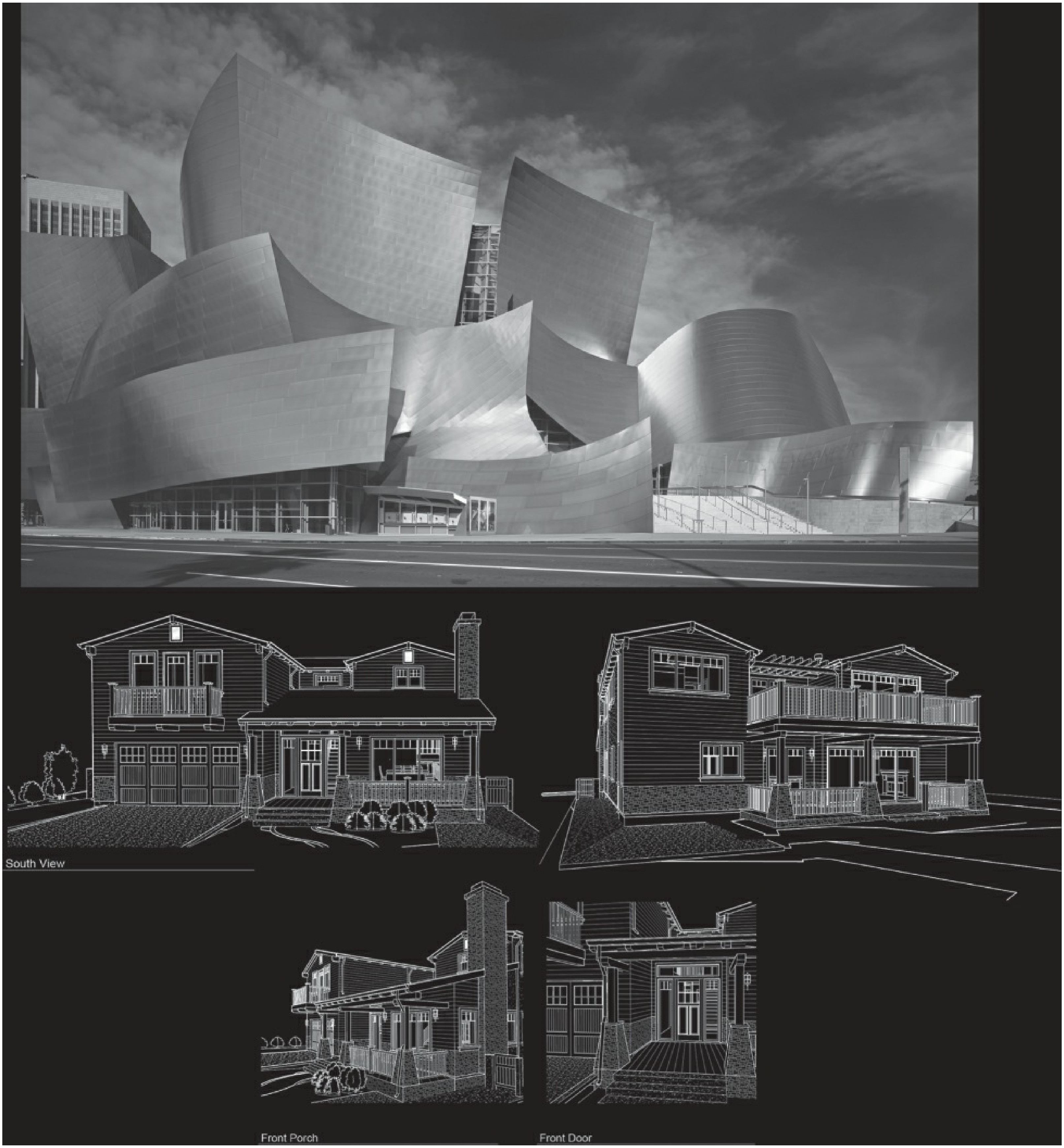
plenum area

pony wall

space planning

tenant improvement

Chapter 15
BIM VIA REVIT



BUILDING INFORMATION MODELING (BIM)

Introduction

The U.S. National Building Information Model Standard Project Committee has defined BIM as follows:

> Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; defined as an existing from earliest conception to demolition.

Building information modeling (BIM) is basically the sum total of what we have learned about how to manage digital representation of both the physical and characteristics of a structure. It is a method that allows the designers and architects to be able to make changes rapidly because the entire structure and its related areas such as engineering, plumbing, air conditioning, and such are resolved early in the design phase of the building. BIM originated as early as 1970, but because of the complexity and the learning curve, it did not come into function until the late 1990s in the architectural industry. It is the finest addition to construction documents since computer drafting was first introduced to architecture. BIM also looks to be a major step in defining the necessary work to be done in our industry. The vehicle used to process this information has been developed by many companies. In this chapter we will discuss a program called Revit, which will be described in detail later in this chapter. Revit is not the only program available to program BIM; programs such as ArchiCAD and Bentley are also vehicles of BIM.

Operation

If this is your first experience with BIM using Revit as the vehicle, try to remember the first time a family member had an urgent need to see a medical doctor. You may recall the MD taking extreme caution and ordering blood tests, checking the heart, and even calling on his associates to do additional testing of the liver and kidneys. So it is with BIM via Revit—the inclusion of every factor in the production of a building, especially during the design phase. As you begin to translate the needs, wishes, and dreams of your client, the architect or designer in the firm will begin to develop a concept on which he/she will develop a field of play, much like a football field or a basketball court and begin to diagram the site to locate the forms with which the original concept will begin to develop. But much like your medical professional, the designer will need to contact his/her consultants and immediately, begin incorporate structural forms, selecting materials, contacting the plumbing and electrical specialists developing a way in which the mechanical equipment with the ducting does not change the design and develop a total approach, using the forms that the designer is using and without interrupting the concept of the structure during the design phase. In a multistory structure, the designer must consider elevator shafts, skylights, and stair locations. In the past, many architects and designers have not included the consultants or professional associates at the onset of the design, therefore causing a need to compromise the design and work these features in

using “change orders” during construction because the air…conditioning ducts were intersecting the pass away of structural members at a point when the building was more than 50% complete. This often causes a compromise of the design and would force a rescheduling of the subcontractors and perhaps significant delays. We must incorporate all of the things that impact the design at the beginning, called “front loading” the contract, and the initial cost of the contract becomes higher at the beginning, but ultimately the cost of architectural construction will be much lower, which will please the client.

National BIM Standard—United States, Version 2

As explained earlier, BIM standards are being written by a multitude of professionals and, as such, are a work in progress. We do not expect the beginner to totally understand what is being explained below; however, it is a small peek into your educational future. After a few semesters in architecture, you will start to understand the challenges that are shown here. For those of you who wish to continue beyond a technician level and have aspirations of getting a baccalaureate degree in architecture, you must master BIM and Revit or some other computer vehicle as you enter the field so that you will be comfortable with the demands of architecture. For those already in the field of architecture, reacclimate yourself to this new world as soon as possible. You can download the entire “standard” online.

A Quick Look at the Standard. The BIM standard is written in by cost estimators, facility managers, specifiers, designers, contractors, project managers, International BIM developments have appeared in Asia (Hong Kong, India, Iran, Singapore, and South Korea), Europe (Hungary, France, Lithuania, Switzerland, the Netherlands, and the United Kingdom); North America (Canada and the United States), and Africa (Nigeria).

The standard is developing patterns that will begin to include all related forms of architecture and incorporating them early, which will require not only great knowledge of the totality of architecture at an early stage but also a tremendous amount of front knowledge, ultimately avoiding massive changes during construction, which in and of itself will change the process of construction and will require more preplanning and costs at the beginning of the project but will ultimately be lower cost on the total budget of the structure. This strategy will also demand a comprehensive understanding of the materials being used and their limits and strengths.

Following is a list of the progress made in the first portion of the standards as of 2015:

Product	**Status**
Timber	Completed
Insulation	Completed
Sheeting	Completed
Flooring/Floor covering	Completed

Windows	Completed
Doors	Completed
Roofing and cladding	In process
Steel	In process
Aluminum	In process
Masonry	In process
Roofing membrane	In process
Foil	In process
Concrete	In process
Stairs	In process
Fireplace	In process
Cupboards, closets, etc.	In process
Equipment and hardware accessories	In process
Others	In process

A digital representation of the physical and functional characteristics of the structure becomes the building information model. This exhausting process is hastened by the use of what is called electronic business—using computers to correspond with your associates. Now designers must establish a new vocabulary among the people with which they speak on the computer, which is called a "dictionary of basic data." Construction information exchange is called "construction operations building information. In the manuscript of the standards, the acronym *COBie* is used, and includes:

Design Spatial Program Validation

Design to Building Energy Analysis

Design to Quantity Takeoff for Cost Estimate

What you have just read is about 5% to 10% of the entire BIM standards. Hopefully, you will not be intimidated by the bulk of the information that is contained but begin to digest the information that will put you giant steps ahead of your competition. If you are employed at this time, you must check with your office manager and ask how much of the BIM standard you, as an employee, should incorporate or if you should follow the existing office manual. If you are not presently employed, you will set your own standards, remembering all the things that go into a BIM standard and developing standards such as those incorporated in this text, plus others that you have learned about such as dealing with the environment and the materials that you will be using. The edge in the profession that you seek is not a matter of just knowing the information but also knowing how to use it. It is our hope that you develop knowledge of BIM beyond the national and international standards, giving you an edge during your employment so that you become a professional and leader that others will follow.

ARCHITECTURAL WORKING DRAWINGS

Prior to exploring Revit, a technical drafter must understand what he/she must do in reference to the entire journey, especially if one's job begins at the preparation of construction documents (working drawings) stage. To expedite the journey, four working drawings—the site plan, floor plan, an exterior elevation, and one building section—have been selected to give the reader a head start.

Site Plan

The site plan

1. Check any field theory and datums that were established by the designer. Validate design patterns used by the designer.
2. Use the office standards or establish your own set of standards based on national standards, such as those produced by the American Institute of Architects (AIA).
3. The site plan shows the contour of the property. See Chapter 11.
4. Confirm any structural, heating, and air…conditioning units adjacent to the structure as well as the location of the water meter, gas meter, and even the electrical lines and electrical panel.
5. The site information should be confirmed with the civil engineer's property line, true north, orientation north, existing structures, and existing trees.
6. Check for easements on the property.
7. Minimum setbacks for the property should be checked via the building department.
8. Locate and dimension the structure and locate any improvements around the structure from the building.
9. Locate all existing trees and identify the trees that are to be removed.
10. Indicate a minimum slope of the slabs or the direction and percentage of slabs.
11. Show the roof if it extends beyond the building.
12. Proper noting is an absolute must.
13. Proper attention should be paid to any special items such as sculptures, fountains, canopies, gazebos, and other such items.

CHECKLIST—Site Plan

1. Verify with the designer/architect.
2. Establish standards.
3. Check with associates.
4. Plot the contour of the property:

a. Orientation
b. Easements
c. Setbacks

5. Locate and dimension improvements.
6. Identify existing trees and trees to be removed.
7. Show roof lines and anything that extends beyond the building.
8. Indicate finished grade elevation and indicate the height of concrete.
9. Identify special items:
   a. Vicinity map
   b. Lot description
   c. Roof slope and description
   d. Title and scale

FLOOR PLAN

Preparing construction documents must always begin with verifying patterns used by the designer. Modules that are used to design the building and/or shapes that are unique to this particular design comprise field theory. The designer may be using the patterns in a different way than you might understand. Review the standards that are used for the floor plan and not those that are already included on the computer.

Construct the perimeter of the floor plan. If the plan was drawn during the design stage, remember the drawing was executed as a family. Your task will be to validate its size against the site plan, elevation, and building section.

Any change in the floor plan regarding stairwells should be researched in terms of the size of the tread and riser plus the landing.

If the floor plan had no interior walls drawn, this should be your next step, along with validating the size and location of the windows, doors, and openings, checking to see that they do not conflict with the structural integrity of the building. Kitchen cabinets, appliances, bathroom fixtures and location of closets, indicating any built…in units within the closet or wardrobe, positioning, shelves and poles will follow. If there is a game room or a built…in theater, how much room will need to be added? Is the seating formal? What will be required on the floor plan? The outline of the roof should be included, and what type and density should be used for the lines indicating the roof? If there is a structure within say 5′…0″, should a partial plan or outline be drawn adjacent to the floor plan that you are now drawing?

Show the proper material designation for the walls, the various changes in the ceiling

plane, and soffits above the cabinets. Use proper notation throughout the drawing, including room titles. Many offices include floor materials in the floor plan. Include the proper title, north and orientation north, and the scale of the floor plan. All of these details must follow the office standard so that the floor plan will match all other drawings.

CHECKLIST—Floor Plan

1. Validate all design dimensions used in the structure.
2. Construct the outside inside walls of the structure.
3. Show interior connections such as stairs and any change of the level in the floor.
4. Show any structural members such as columns.
5. Indicate windows, doors, and openings in the wall plane.
6. Add kitchen cabinets, built…in appliances, and losets.
7. Show all bathroom fixtures.
8. Indicate any change in the ceiling level, including soffits, and cabinets.
9. Indicate the proper standard for the material being used, such as wood, steel, masonry, or composites.
10. Include section lines, partial sessions, and detail references.
11. Use Proper notation, including room titles and sometimes floor material (possibly located in the schedule).
12. Show proper title, scale, and north arrow.

Elevation

After having dealt with the site plan and floor plan, which predominantly focused on two of the horizontal measurements—width and depth—our journey takes us to height and width or depth. You must begin to understand what standards we will incorporate herein. Check the standard used in drafting an elevation.

Finding the vertical datum becomes the major task on our journey through elevation while validating one of the two other dimensions (width or depth, depending on the direction that you are viewing the elevation).

The first vertical datum usually deals with the earth (bedrock, frost line, natural or finished grade). The floor line is then found. The structural and geological drawings are used to validate this, as is the building section if available. The floor line is based on the above and is showed as a datum. The plate line is usually next, followed by the next floor line, and this rhythm continues no matter how many floors we have in the structure.

CHECKLIST—Elevation

1. Verify the size of the structure with the site plan and floor plan.
2. Verify the vertical datums established by the building section.
3. Draft the vertical datums.
4. Locate bedrock, frost line, and natural and finish grade. Validate with structural and geological drawings.
5. Draw the floor line based on the previous step.
6. Position.

Building Section

As before, you must establish the standard that applies to building sections. Check to discover the datum that have already been established. This can be done by checking the building section with the elevation. In most sets of drawings, the building section is done prior to the elevation and confirmed with the designer/architect to find patterns that have already been established as a datum and verified with the structural engineer, mechanical engineer, and all of the other associates.

Continue by outlining the building beyond the structural form that you just performed. Since a section is visualized much like a knife slicing through the building, you should concentrate on that which was sliced and becomes the darkest lines on the drawing (all others should be much lighter based on how far they are behind the dark section lines.

If the section cut through a window, door, or opening, the framing should be shown. Do not show objects beyond the cutting plane unless the object has a direct impact on the structure itself.

If there are structural members coming toward the viewer, such as floor joists, be sure to show them with the same emphasis as the other structural members. If possible, add the outside cladding to the building, such as stucco, wood paneling, or dry wall. Depending on the scale of the drawing's cladding, it may be difficult to show on this drawing. Thus, you must use your own judgment to indicate the outside covering using just an indication of the material. To this end, you will be able to understand why a wood…framed structure is dimensioned to the stud line and the center of the stud on the floor plan. You should now add texture to the elevation portion of the section, but do not include the entire area; indicate only a small portion using a brake line, leaving it for the next stage, which is notation. Complete the drawing following the standard used on the entire set of drawings and position the title and scale.

CHECKLIST—Building Section

1. Verify standards.
2. Verify vertical datum.
3. Validate vertical and horizontal measurements.

4. Check with engineering drawing.
5. Construct a structural outline (verify with number 3).
6. Finish outlining the building.
7. Draw the rest of building outline not cut by the section.
8. Show the windows and doors cut by section.
9. Do not show furniture or objects beyond the cutting plane unless they impact the structure.
10. Add the end view of the structures that are seeing coming toward you.
11. Profile the structural parts and add texture to the inside of walls.
12. Add texture to those portions that will be seen as elevation.
13. Provide the required notation.
14. Provide the Title and scale of the drawings.

Modifying Revit Standard

The drafter must make the necessary changes after downloading the Revit program. When you open the program, you will be greeted with the recent file screen, as explained in the pre…Revit portion of this text. Here is one of the first areas where you can start modifying the way you interact with Revit. It is recommended that you follow a work flow. The first step is to open and create a template or modify a template that has been provided for you by Revit. Each individual template will have different functionalities. You can create your own template or use a predefined template by going under the project portion of recent file window to your left. See Figures 15.1A and 15.4B. If you are already employed, a template may have been predetermined by your office. If you are creating a template from scratch, you will need to input a lot of information into the program at the beginning. It is sometimes recommended that you use an existing template and modify it to fit your needs. See Figure 15.2, which shows the different functionalities that are found in a few templates. These functionalities can be found under your project browser.

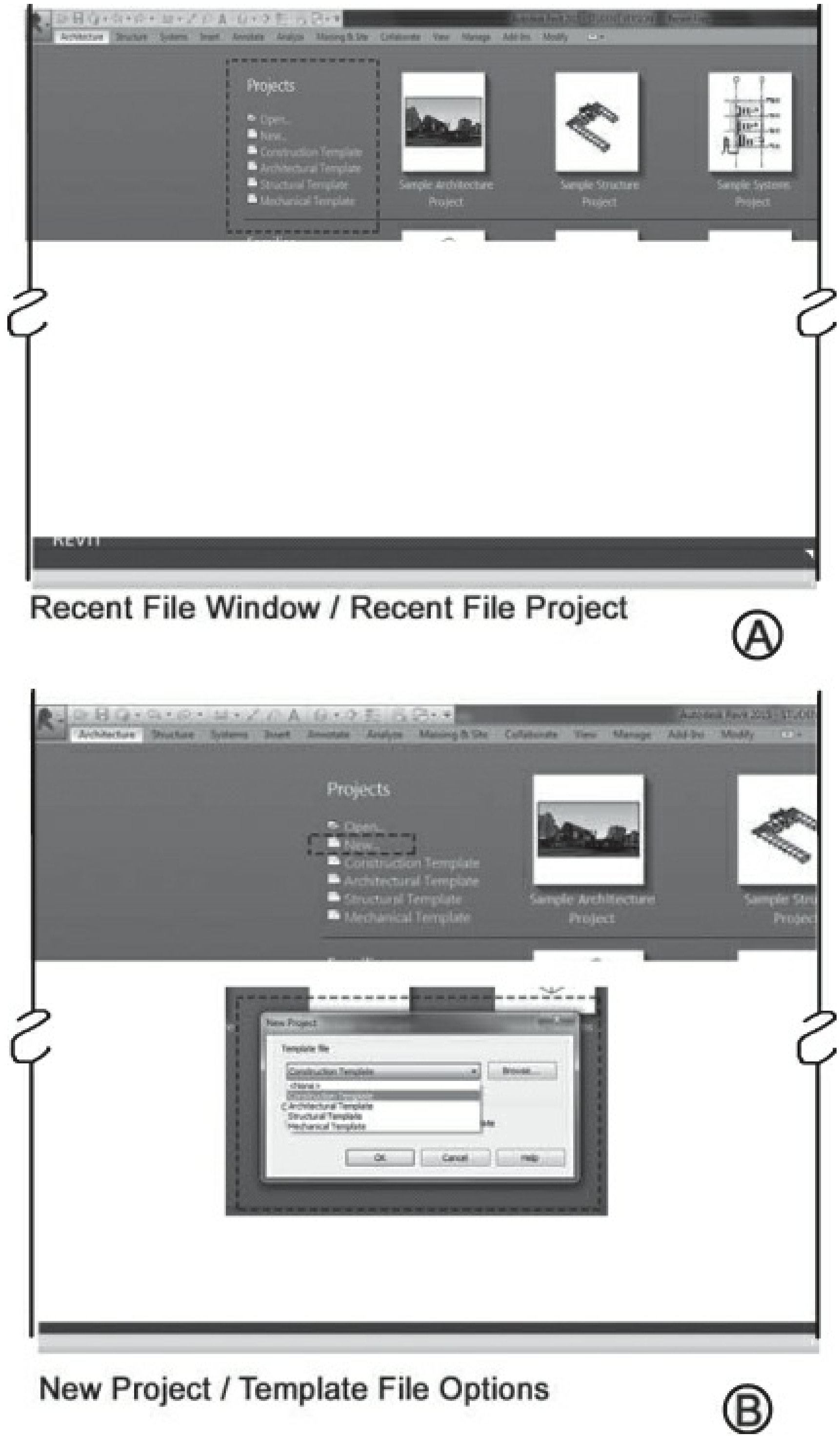
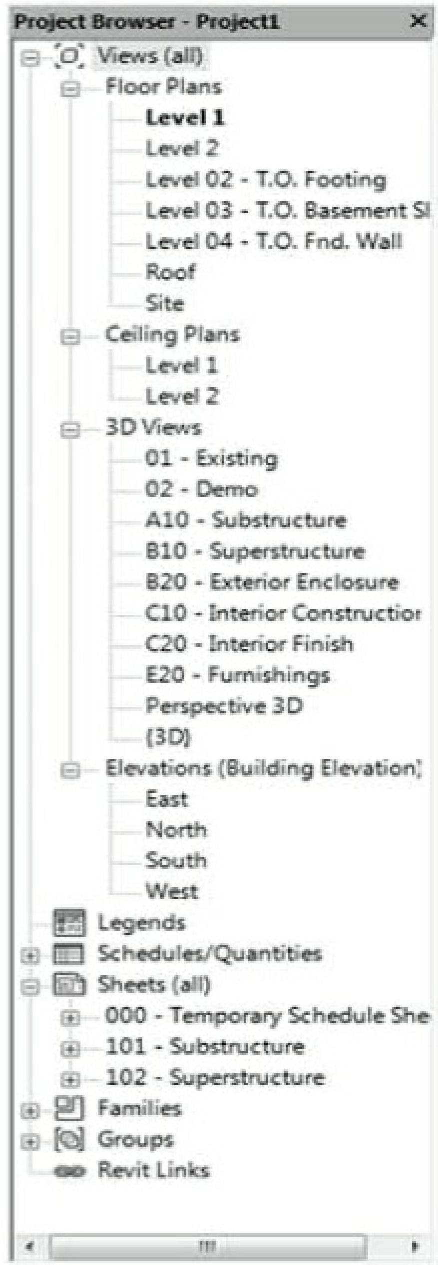
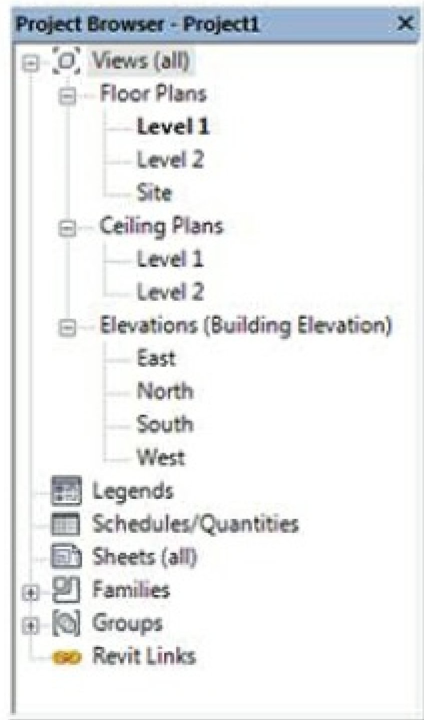


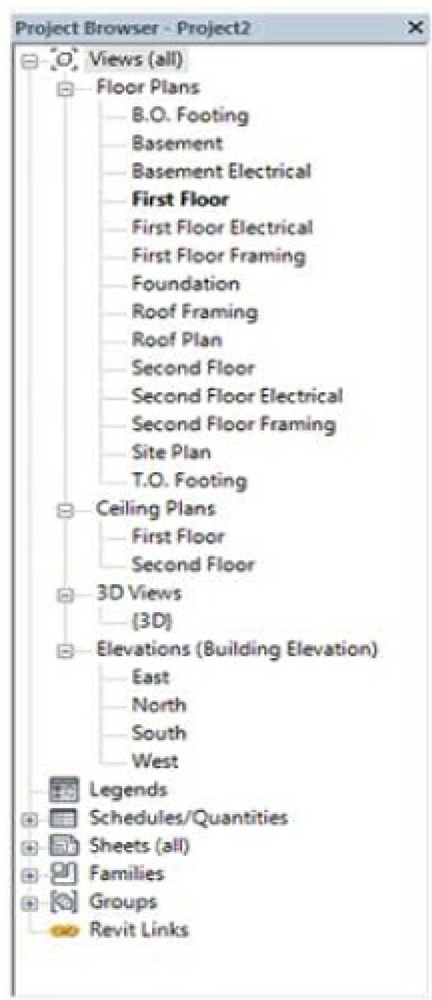
Figure 15.1 Working with templates.



Construction Template



Residential Template

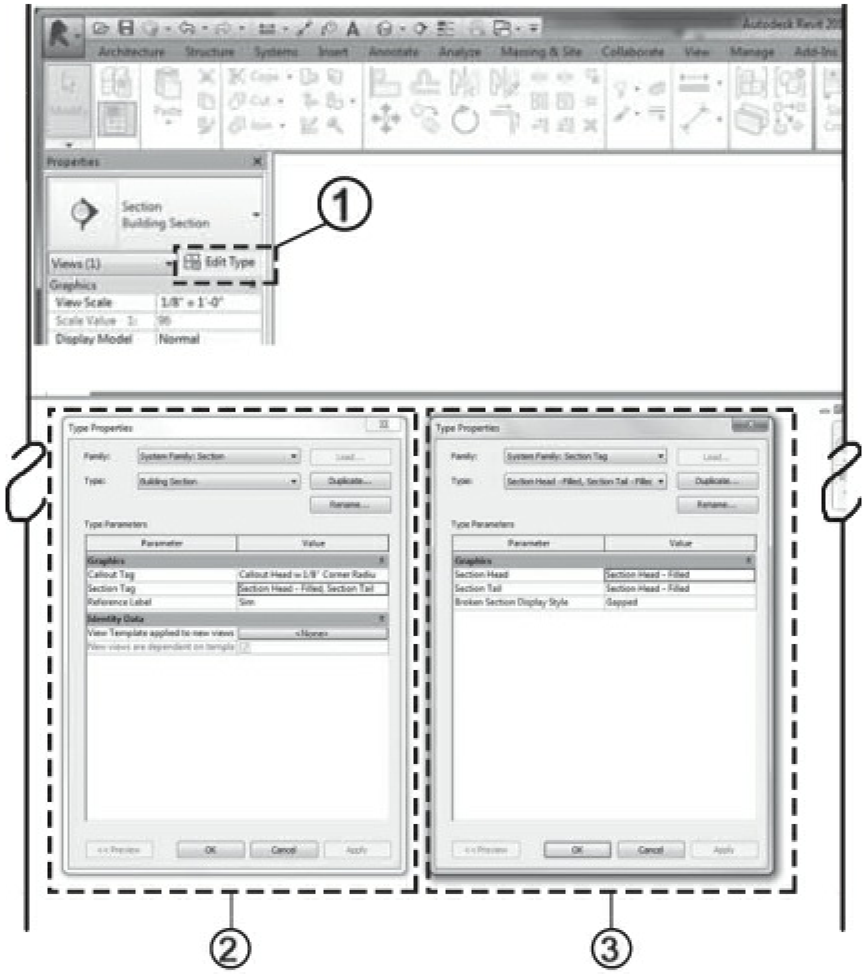


Architectural Template

Figure 15.2 Templates and project browser samples.

Think of a template as a predetermined drafting manual that will determine the pages to

be used, title block, annotations, materials, and specifications. You can modify the standards predefined by Revit to comply with the actual architectural standards. One example in modifying the standards given to you by Revit is shown in Figure 15.3. Please note that most of these modifications will be done under annotations.



1. Start by selecting “Edit type”
2. Select “Section Tag”, under “Type Properties”
3. Choose tail properties

Figure 15.3 Modifying section annotation.

For example, Revit uses a convention to cut a section in a drawing, as shown in Figure 15.4A, which represents a partial section. In the industry, this might work, but it is not technically correct. Figure 15.4B shows the correct symbol for a full section: a cutting plane line that has a broken dark line with two short dashes. The ends are made up of a pair of circles bound by darkened triangles. This section is a full section, cut through the entirety, as opposed to a partial section, which has the triangular form around a circle on one side only. The full section title has an “X” on both sides, and thus the title of that section is Section X…X. This also helps to alert the contractor and crew to look at both sides to see if it is a partial section or a full section. The arrowheads also show the direction one is looking when viewing the section. Figure 15.4C illustrates another section detail in which the darkened beak shows the direction in which the detail is being viewed. The outside of the building on a detail is always to the left.

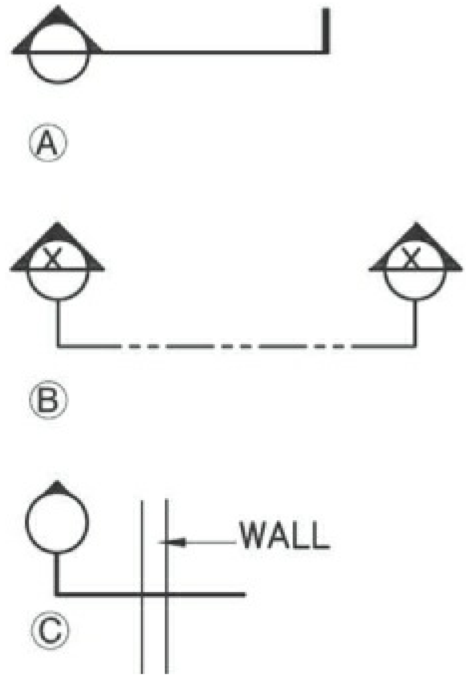
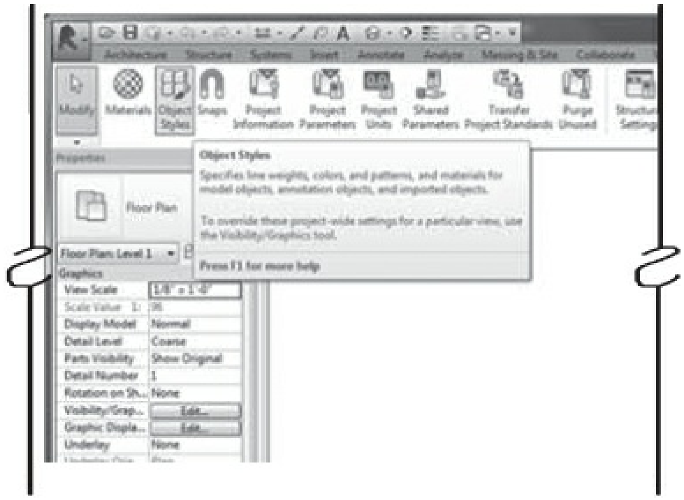


Figure 15.4 Standard section call…outs.

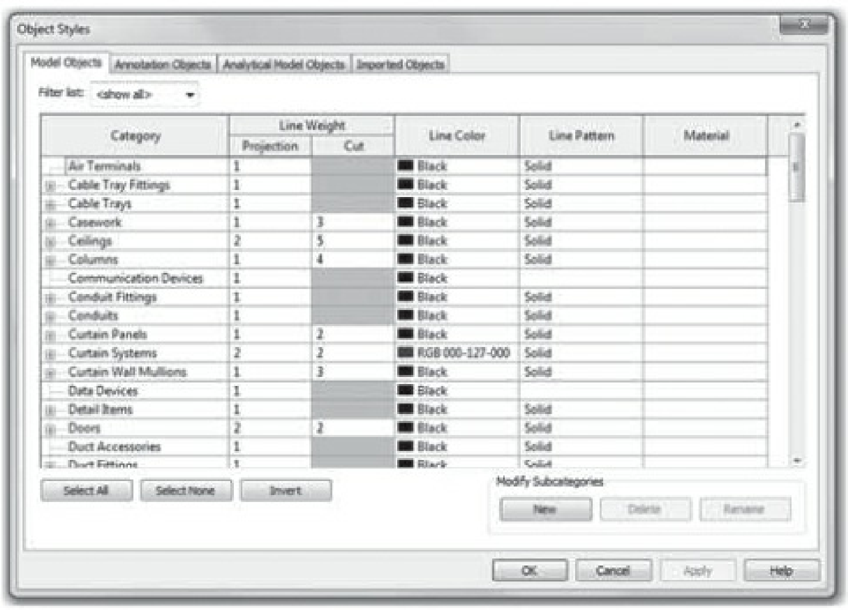
One would think that since Revit is programmed by Autodesk its drawings are produced for national use, but these drawings must follow the standards that are indicated by deans and practicing architects from all over the United States, many of whom are Pritzker Prize winners. Individuals who are just entering the field of architecture can use the standards that are used throughout this text. Professionals already in the field should look at the standards that we have included in Chapter 2. The drafter must take into consideration the density of lines and the type of lines used for a section. Each line is drawn for a particular reason. The section line uses a broken line so that if there is a dimension that the line will cross it will not cross the line because the dimension line takes precedence over the section line so as not to confuse the builder. If you are employed by an architectural firm, check their drafting room manual and the standards to which the office subscribes.

Modifying the way your drawing will be drawn and printed can be a task that can take some time, but once these changes are saved to your templates you will be able to use them every time. One of the most important modifications that must be addressed, other than standard annotations, is line weights. Modifying your line weights will require some thinking since the lines that you see on your screen are actually three…dimensional (3…D) forms rather than lines. In Revit, line weights are modified to the different type of scales you will be using. A quick view on modifying line weights is shown in Figure 15.5. This is done under the manage tab under object styles. Refer to Figure 15.5A. Pen settings are changed based on your object styles; these are your model objects. There are categories built into the system; see Figure 15.5B. Familiarize yourself with the object style window and review the way you want your lines to appear in projection and cut. Each of these line weights is assigned a number that can be modified under the line weight window; see Figure 15.5C. You can get to this window under the manage tab, and going to additional settings here you will find the line weight option. Under the line weights window you will find the model line weights tab; this is where each number is assigned a line weight based

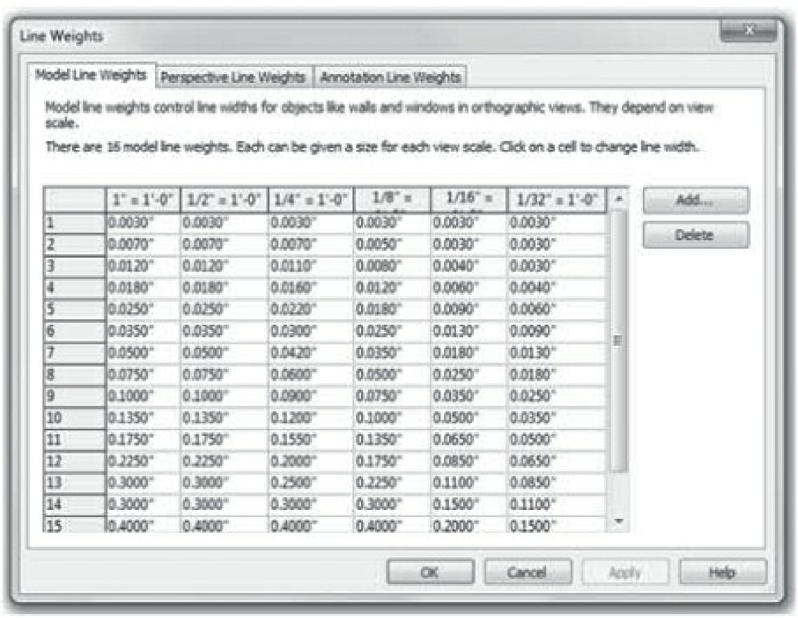
on the scale you are working on. This is a quick review on line weights, but it can be a very extensive learning experience. We recommend you explore this portion of Revit in more detail since your drawings will be greatly impacted by the way you manage your line weights.



Ⓐ Object styles under manage tab.



Ⓑ Object styles window



Ⓒ Line weights window

Figure 15.5 Revit object styles and line weights.

PRE–REVIT

A very important note to those who are new to the field of architecture and are planning a career: Sometime during the time you are preparing working drawings, you will not be able to reprogram Revit in a fashion that meets your needs. This means that the information you learned in class was not comprehensive enough for you to be able to translate or the tutorials that you watched did not cover it thoroughly enough. Some of these difficulties that you might be experiencing are not due to learning a new program but to understanding the how the application affects your workflow and being able to manage the change.

Our first advice is to go back to your tutorials or your computer class and ask your instructor to definitively (during class) explain your problem. Another resource is to call Autodesk and ask how the problem can be solved. The information you are seeking may be beyond your reach at this point in your career.

There are a number of things that one must accomplish before they use Revit. The use of a checklist is but one of these. This is similar to a pilot and copilot preparing aircraft prior to a flight. They will visually check the aircraft inside and out, using their checklist, regardless of their experience. In this fashion, the pilot can be compared to an architect, as both individuals are responsible for the health and safety of the people they serve.

In architecture, the responsibility flows down the employee hierarchy and makes even a technical draftsperson responsible. Previously, a checklist was provided for our construction documents. We have selected the proper avenue you should follow as we walk you through the process. If a model has already been drawn, your task will be merely to validate and continue your journey to produce construction documents. To simplify your journey, we will begin with only the site plan, floor plan, elevation, and building section. Certainly, there are others, such as roof plans and framing plans, but in this section we selected the four drawings listed above to give you a slight start.

As you begin preparing to draw the four drawings above, if you are already employed, the firm may already have the documents prepared, but if you are still in school and are beginning to develop your Revit skills, it becomes absolutely necessary to digest and use your newly developed checklist each time you begin to use Revit.

The four drawings will be done simultaneously. If you have but one monitor, each of the drawings appear in one of the four quadrants. Most offices now use multiple monitors so that they may see four or more drawings simultaneously.

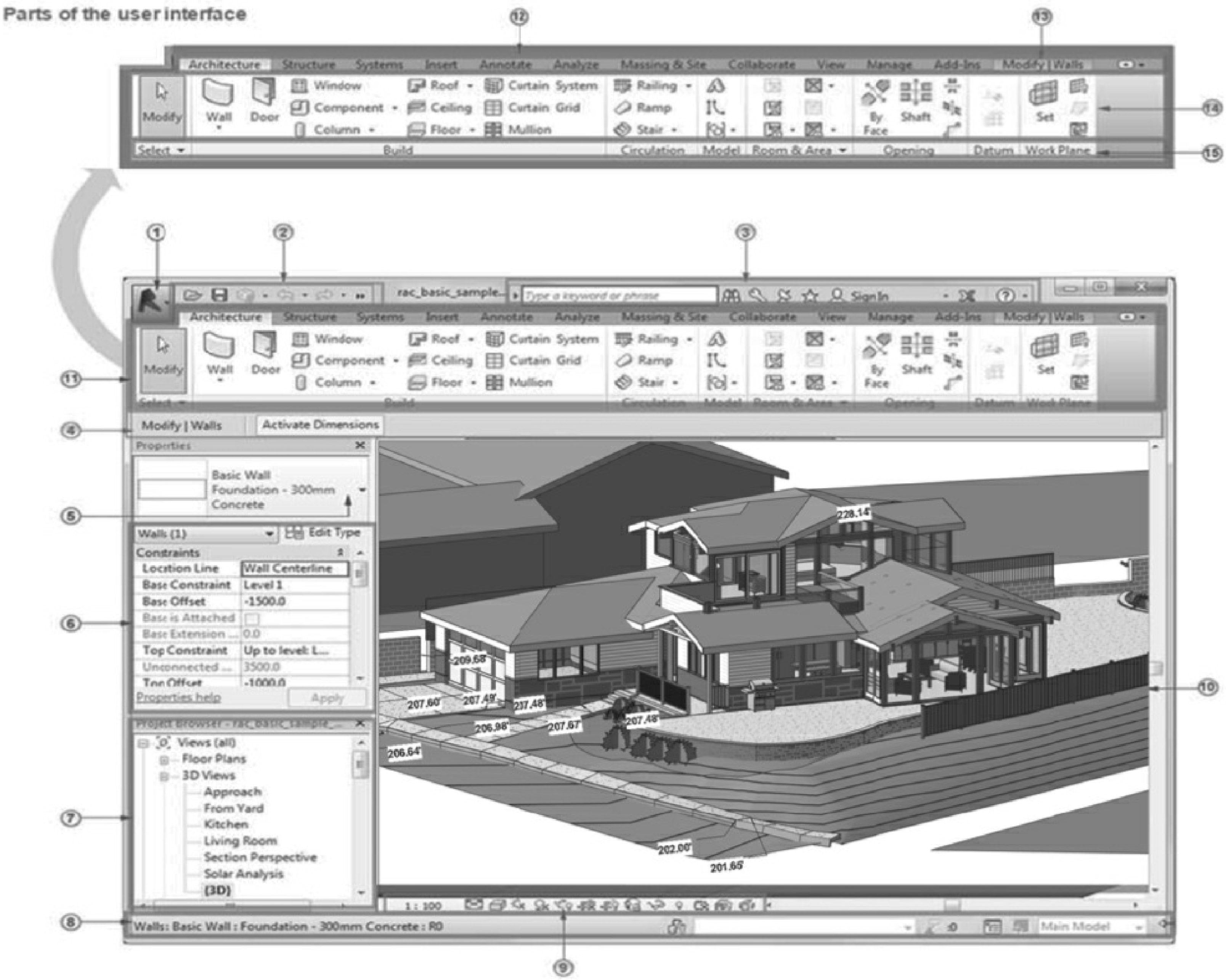
Although you may be familiar with AutoCAD, you cannot use the same skills on Revit. The techniques are completely different and will cause you much frustration. In AutoCAD you can easily change the standards, such as the AIA standards, you may want to use.

Revit has standards already built into the program that may not be correct. To change or correct something drafted in Revit is difficult. Whether AutoCAD or Revit is being used and the document is reproduced, using a printer, 15% or more of the copies may be incorrect in size at a particular scale, and this image cannot be used to show your clients, as a 50 × 150 may size at 39 × 142. This is all based on the manufacturer of the printer and your computer. In order to validate your printer/computer, produce a drawing at 1/4 scale, then print it on your printer or plotter, and, using an actual scale, measure the printed copy; you will find that your printer or plotter is often incorrect. At any time during the drawing lifetime, one should always prioritize the written text and not allow the contractors to scale the drawings. For this reason, it has often been suggested to present to the client pictorial drawings and diagrams done freehand so as not to mislead your client. If your client is a technically trained artist or anyone who understands proportions, he/she will not be happy with the finished product, as that was not the proportions he/she was introduced to.

As you study Revit, remember that you must think in 3…D, even though eventually the drawings you produce for construction will be 2…D. This 3…D visualization of documents is new, especially to beginners; in the past, drafters drew and thought two…dimensionally. In CAD, you set up a series of geometric forms; AutoCAD does not care what it represents. In contrast, in Revit you create elements. AutoCAD eventually is a virtual drafting board where your lines are drawn in a two…dimensional plane.

Because BIM implemented via Revit is so front…loaded, the design development phase must be done by a person who is very knowledgeable about architecture, be it the project architect, the designer, or the architectural technician. The person using Revit must know what the building constraints are before he or she begins to work.

With Revit a new language has to be learned, as may be the case with other software. The terminology used with Revit often does not match the terminology you are used to hearing in architecture or in using AutoCAD. To begin, the end user must become familiar with the terminology used in Revit. One of the first steps is to learn your Revit interface. See Figure 15.6, which shows the Revit interface window with a list of terms you will need to know that you will commonly hear while using Revit.



1	Application Menu	9	View Control Bar
2	Quick Access Toolbar	10	Drawing Area
3	InfoCenter	11	Ribbon
4	Option Bar	12	Tabs on the Ribbon
5	Type Selector	13	A contextual tab on the ribbon, providing tools relevant to the selected object, or current tab of the ribbon
6	Properties Palatte		
7	Project Browser	14	Tools on the current tab of the ribbon
8	Status Bar	15	Panels on the ribbon

Figure 15.6 User interface window.

REVIT

The term **Revit** comes from “Revise Instantly,” which the program accomplishes as changes are made. Move one door and Revit will reflect the change in all other drawings. This is because Revit creates relationships within objects and between objects. If you

were to call out (tag) a wall to be made of wood studs with stucco on the exterior and drywall on the inside, all walls would be affected (although you could change one particular wall from drywall to wood paneling).

In order to start a BIM model, you need to talk to all your associates, the engineer, and all the individuals that will have a direct impact on the structure prior to the design phase. How does one start? You can start by using one of the programs that are available. We will start by downloading a program called Revit. A novice in architecture must become a part of the Autodesk community. By doing so you will have access to Revit for a limited time at no cost. This means that if you are enrolled in an accredited college, authorized by the government, you can get the program by contacting Autodesk and validating your enrollment. There is no cost, of course, but use the time wisely. Of course, after you have had enough courses, you can make better use of your enrollment on Revit. Go to the Autodesk web site and create an account and register for the Autodesk Education Community. At the top of your screen you will be asked to input your personal information, including whether you are a student or a faculty member. If you are a professional, you can also download the Revit trial version, which allows you to use the program for 30 days. There are different types of Revit versions that you can download depending on your needs (different versions will have different functionality disciplines/tabs):

- Revit: Building Design Suite (Autodesk Revit)
- Revit: Architecture
- Revit: LT new comer (similar to Revit: Architecture)
- Revit: Engineering MEP (mechanical, electrical, plumbing)
- Revit: Structure

Building Design Suite is the version recommended, as it will have all of the functionalities from the versions listed above. You can turn off all of the functionalities you don't need and use only the parts of the program that fit your needs and your architectural education level. Use this trial version carefully; later, we will describe what, in reality, you need to know to go on in Building a 3…D Model by way of Revit. Beyond this point, you must realize that you need a bit more background in architectural theory before you start using Revit. This professional program will cost around $7,000 to $8,000 per license.

Go to Figure 15.7A and B, which show the Revit icon as it may appear on your desktop after you have downloaded the program. When you click on this icon, the program will load and you will be greeted by the recent file screen. See Figure 15.8. On this screen you will find your Projects and Families and their respective templates. In the middle portion you will find a few thumbnails of your most recent files, and most importantly on the right…hand side you will find the resources window, which will become extremely helpful as make your way to become proficient in Revit. Under the resources tab you will find videos, tutorials, and forums. There are other resources outside Autodesk such as books,

Internet course subscriptions, and a mobile application that will help you navigate through Revit. Remember to validate the source of the information. Many videos found on social media might have been created by amateurs in the profession. Good resources will be those found in Autodesk and those course subscriptions such as Lynda.com, to name a few.

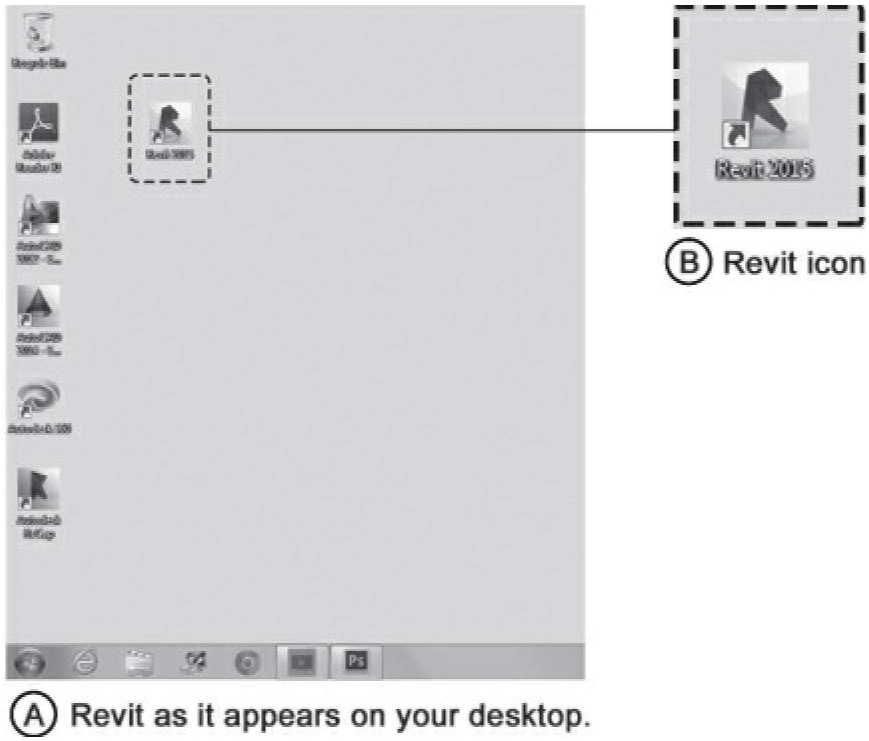
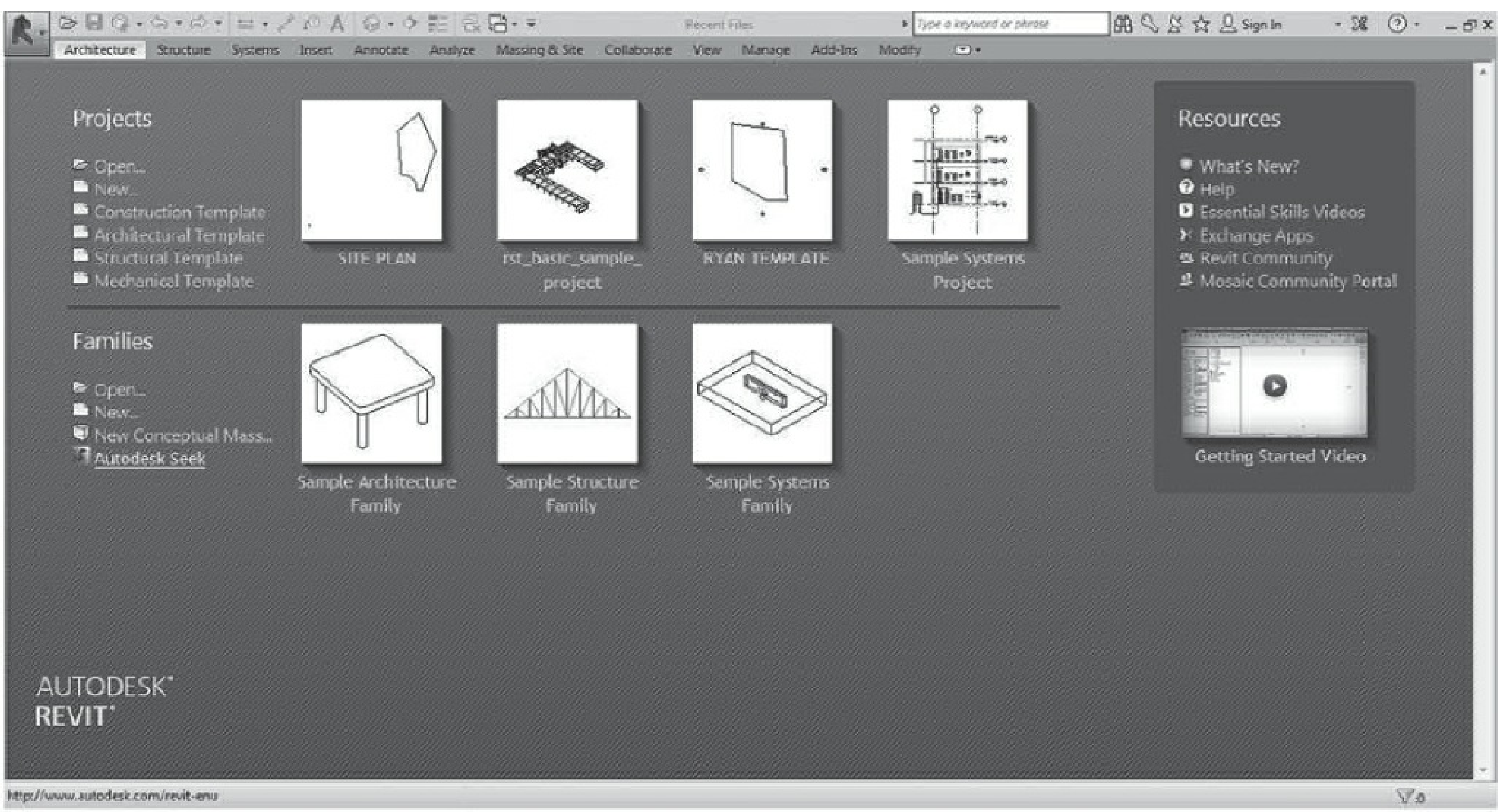


Figure 15.7 Loading Revit



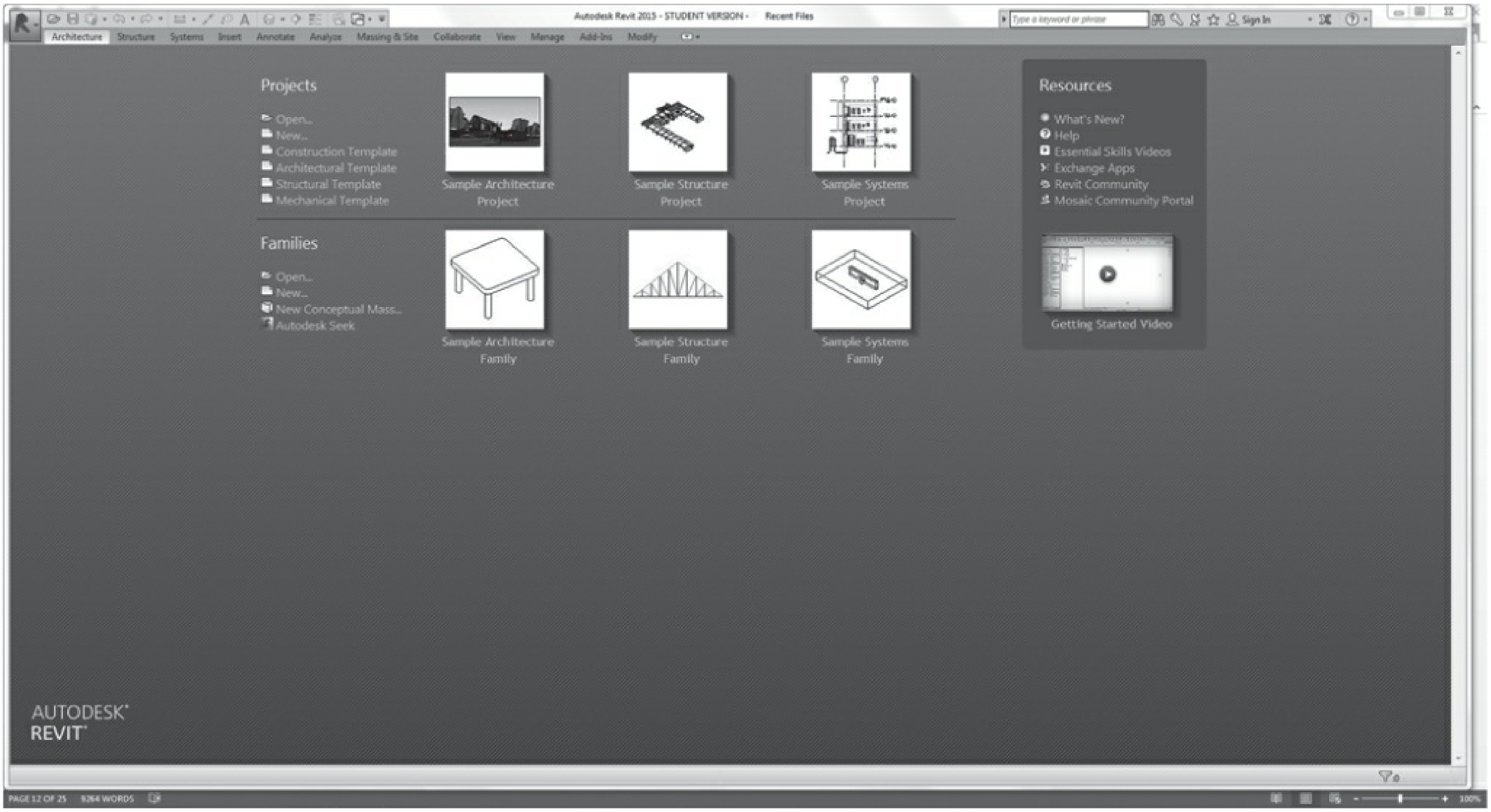


Figure 15.8 Recent file window.

So now you are ready to strike out on your journey through Revit. Remember that Revit is only as good as the user and the information the user puts into the program. As a Revit 3-D model is being developed during the design phase, develop guidelines during the design process, using standards that you may have developed earlier, or use the Office Drafting Room Manual if you are employed. The guidelines may also be called Architectural Design Standards.

If you come from an AutoCAD background, please understand there will be limitations that exist between the two programs. It's noteworthy that you will not be able to work the same way in Revit as you do in AutoCAD.

When you begin to draw a floor plan, include all interior walls, built of wood, masonry, or steel. Of those structures built of wood, you will begin to describe the exterior covering called cladding. Thus, you are drawing a floor plan that is now built around what is called a “Family.” You must draw a minimum of four an additional drawings. So as you draft a floor plan, validate the size and shape and be sure it will fit on the site properly. Revit will also draw a building section and elevations to ensure accuracy of the structure. A common way that this can be accomplished is to split the monitor into the images that you are drawing. In a large office, most computer stations are equipped with multiple monitors to enable the user to use multiple images of various drawings, which allows that technician to look at any drawings at. All of the drawings are integrated in such a fashion that changes in one drawing will immediately reflect in the other. For example, if you were to locate a window on the floor plan, it would show on the exterior elevation. A

feature of the Revit program is that changes in each individual drawing are reflected in all other drawings. You can monitor your drawings and changes in different views by displaying all of the drawings on the screen. You will have the ability to zoom in and out of any drawing in progress. You will find all your drawings in the project browser and can view them simultaneously by clicking on the view tab under tile. See Figure 15.9, which shows drawings organized in a tile view.

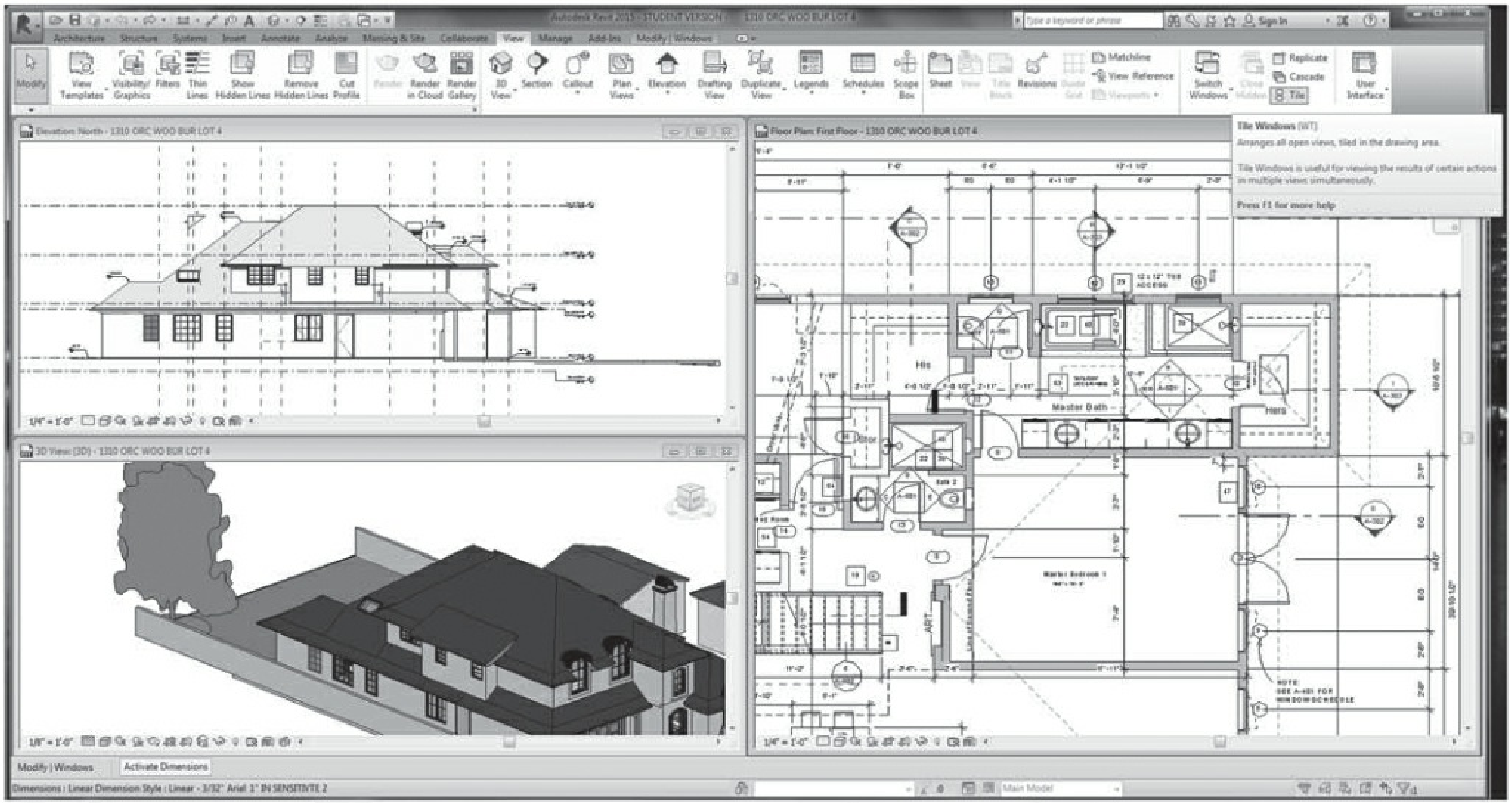


Figure 15.9 Multiple view windows.

As you work in Revit, you must periodically save your work as an RVT (Revit) file. A new template will be saved as an RTE extension. As you draw in Revit, you are simply adding more information to this complex 3…D model.

Go back to Chapter 3 for a quick review on environmental considerations. There you will find a quick sampling of sun studies via Revit.

Construction Document Standards

As you change the BIM/Revit design model to construction documents, it is essential that you take the partial standards displayed below and develop them to meet your needs.

Generic Standards for Construction Documents

- Lettering height
- Max./Min scale of document
- Materials in section

- Graphic symbols
- Abbreviations
- Dimensioning, grouping of dimensions, size and location
- Dimensional reference system
- Metrics
- Drawing sheet size
- Standardization used in the electronic world
- Human concerns—Americans with Disabilities Act (ADA)
- Use of energy—energy conservation
- Sustainable/green architecture

Now that we have introduced a generic standards list, you now have the task of taking this partial list and customizing it for your use. If you are new to the field of architecture, you have a variety of choices to select based on where you are in your education. A relative beginner in architecture must produce a checklist prior to attempting Revit. Ask your instructor if this is an assignment. If this is the case, you might ask your instructor what he/she would like you to use as a datum for this task…specific assignment and what standard should be used as its datum. A sophomore or junior will certainly study the various ways floor plans, elevations, and sections are drawn and adapt the chart to those specific items. For example, if you are setting up standards for a floor plan used for construction documents, you must set up lettering and the font used for all other drawings, not just a floor plan, and establish whether this drawing will be measured in metrics or the English (Imperial) system, the scale, and the paper size onto which the floor plan will be printed. Will you use the dimensional reference system, and what energy conservation considerations will be used during construction? Will there be handicap considerations on this project? Don't use the building department recommendations for slopes on ramps, as the building department is giving you the absolute minimum that will be allowed, which may not accommodate the handicap adequately. The author can attest to that because recently his mobility has been reduced and he spends the bulk of his day in a wheelchair. One in 12, which is the ratio of the angle, is the absolute minimum ratio. Even 1 in 14 may not work for many wheelchair…bound individuals.

If you are a graduate of an architectural school and ready to enter the workforce, the size of the office may dictate the standards being used or they may already have their standards programmed in the computer. The newly formed Revit may have been reprogrammed to accommodate the office standards and their uniqueness to the architectural field. All of this may sound very complicated, but it creates a uniform approach by all the employees of a firm. Small firms often produce a drafting room manual. Having looked at this portion of your architectural education and including it in

your autobiography (vita) will certainly give you the edge when you seek employment.

REVIT—WORKING DRAWINGS

This section is devoted to describing the use of Revit in the development of working drawings. Remember that the partial working drawings checklist is the subject we are addressing, and Revit is the technical tool that we are using. To start, we address the steps in preparing the necessary ingredients for working drawings for those beginning individuals who are working in the realm of Revit for the first time. Since working drawings have been discussed previously, we will limit our discussion to describing the use of Revit exclusively in developing a site plan, a floor plan, an exterior elevation, and a building section. Yes, we realize that there are other drawings, such as foundation plans, roof plans, floor and roof framing plans, grading plans, and so on, to complete a total set of working drawings. At this stage, we will presume that you have the information from the architect/designer who has provided you with the other drawings. This approach was used because the purpose of this portion of the book was mainly to show a beginner in Revit the attitude needed in the formation of working drawings using Revit. There are other programs available that are being used in architecture such as Bentley, ArchiCAD, and VectorWorks, among the various programs that are available and used by architects. We have obviously selected Revit.

The attempt herein will be to expose the beginner to the correct separation of creating, designing, and the pure study of architecture and the pure technical skill of Revit. In this manner, the book weaves learning and technical scheduled knowledge in a manner called a deconstructive forming in education. Thus, we will pursue that which is needed in the technology of Revit as we develop a plan for our journey through the technical aspect of the creative part of architecture.

Therefore, it is critical that, before you go on this journey, you review the various parts of BIM and digest what will be expected of you in the production of working drawings. In this manner, the book will try to explain how working drawings are trying to convey to the contractor and their employees and subcontractors how the structure is to be built and how to articulate that knowledge in our drawings. Learn the language of architecture.

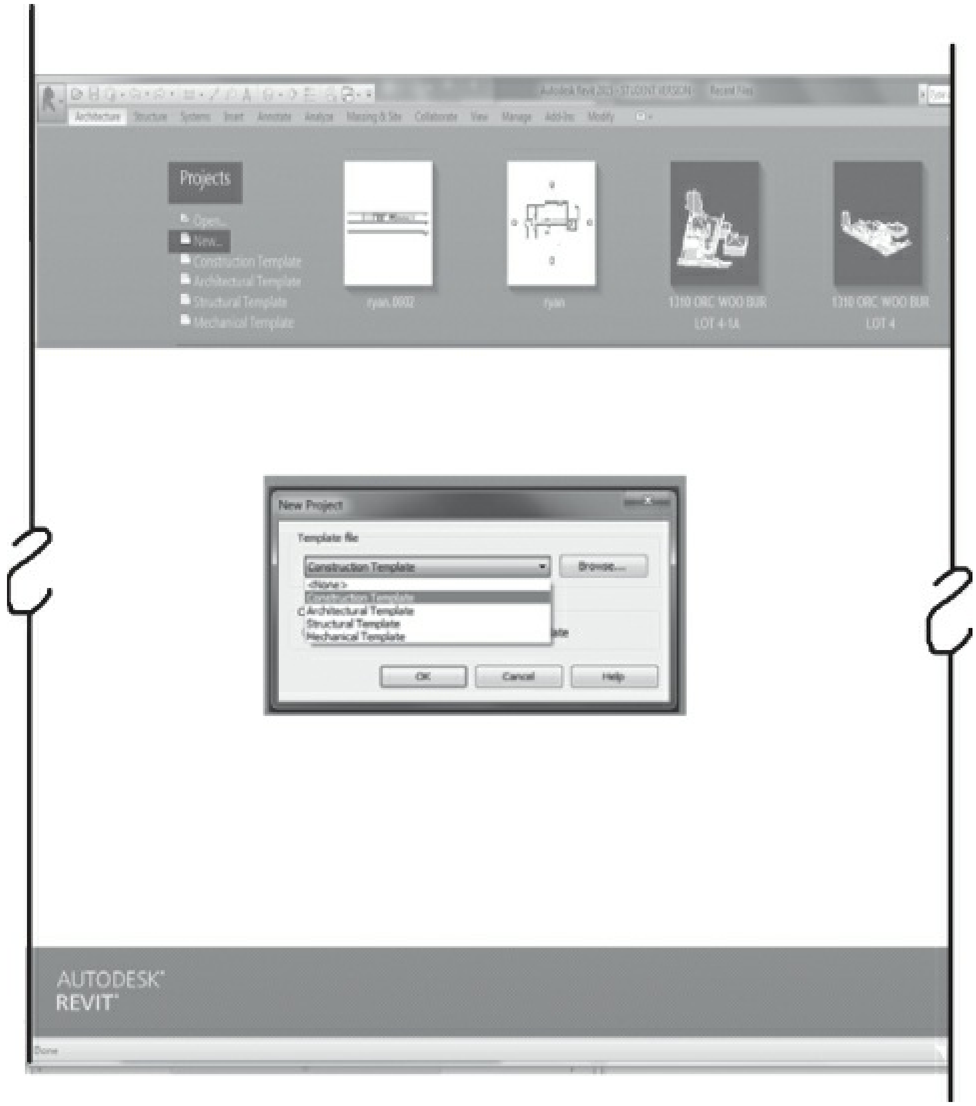
If you are hired by an architectural firm, you must reaffirm that the standards aligned themselves with the drafting room manual. Next, be ready to create a new project. Familiarize yourself with the Recent File screen, which is the first screen that appears when you first open Revit. Revit provides you with predetermined templates to start a project; you can use these templates to start your project, create your own, or use the templates that are provided to you at your workplace. These templates will have predetermined standards, and different information can be provided under different templates. If you are starting a template from scratch, you must review all standards.

Preparing the Revit Program for All Architectural Drawings

Of course, you begin by downloading Revit. Prepare the program by changing all of the standards you will need to use your newly found program. Never presume that what is in the computer is correct. Review Chapter 2. If you are hired by an architectural firm, you should base the standards on the drafting room manual. Review Chapters 3 and 4. This will help you incorporate sustainable/green architecture plus human concerns for the elderly and handicapped and now comes under the ADA, which is enforced by the federal government and has become a constitutional law. See Chapter 4. Now browse through Chapter 6 to understand the preparation of construction documents under which working drawings can be found. Chapters 7 through 14 must be reviewed. Chapter 14 discusses tenant improvement and additions, alterations, and historical preservation, which often becomes a specialty of some architectural firms. Now include in Revit the newest standards available to you, including all facets of design and graphics in clearing the very special terms you will be challenged to master. This may sound very cumbersome to you, but there are no shortcuts. If you are a student in architecture, it may become necessary in your classroom to challenge the instructor and ask him how this is to be accomplished.

Site Plan

Now that you have reviewed all of the above information, the book embarks on the journey of drawing the site plan, purely paving the way with screenshots of Revit. At this stage, locate the Revit icon after opening the Revit program, locate the construction template under the Projects section, and click on it with your mouse. See Figure 15.10. If you cannot locate the construction template, you can find it by going to Projects, New, and a window will open where you can choose the construction template under the template file window. See Figure 15.11. There are several steps in this preparation. At this time, a project file window will show on the screen. This is where your project will begin. Familiarize yourself with this window since this is where most of your work will be done; review all the tabs. At this point we will start setting up our project. We will start with the property information. Under the manage tab, you will find the icon called Project Information. See Figure 15.12. There you will give the project a title, name, status; most of this information will appear in the title block. Then you will need to set up site location. This will be an actual geographic location of the site, and you can check the accuracy of the site location if seen from above, called a bird's…eye view. Technically, this is referred to as pictometry. See Figure 15.13.



[Figure 15.10](#) Starting a new project.

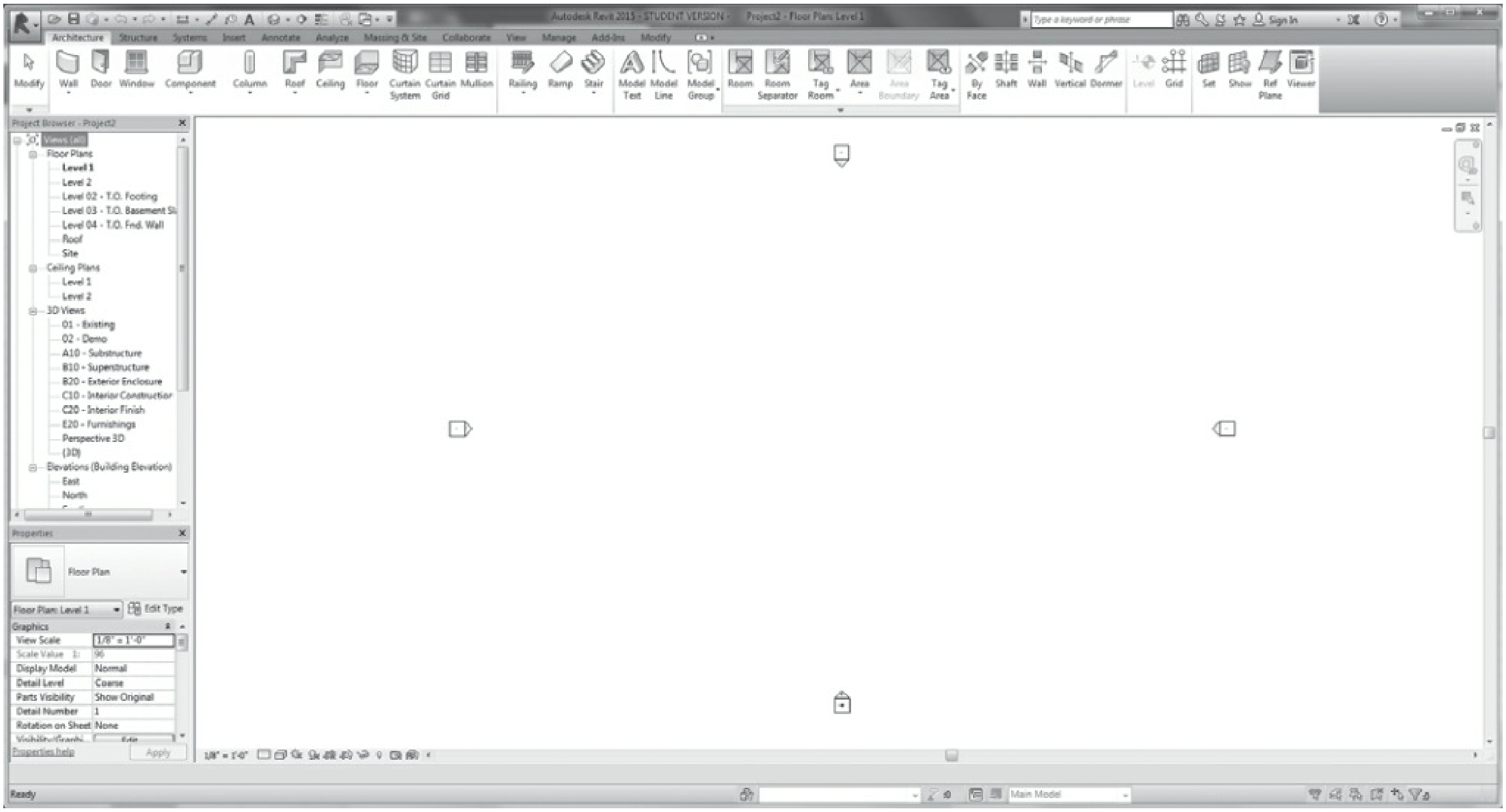
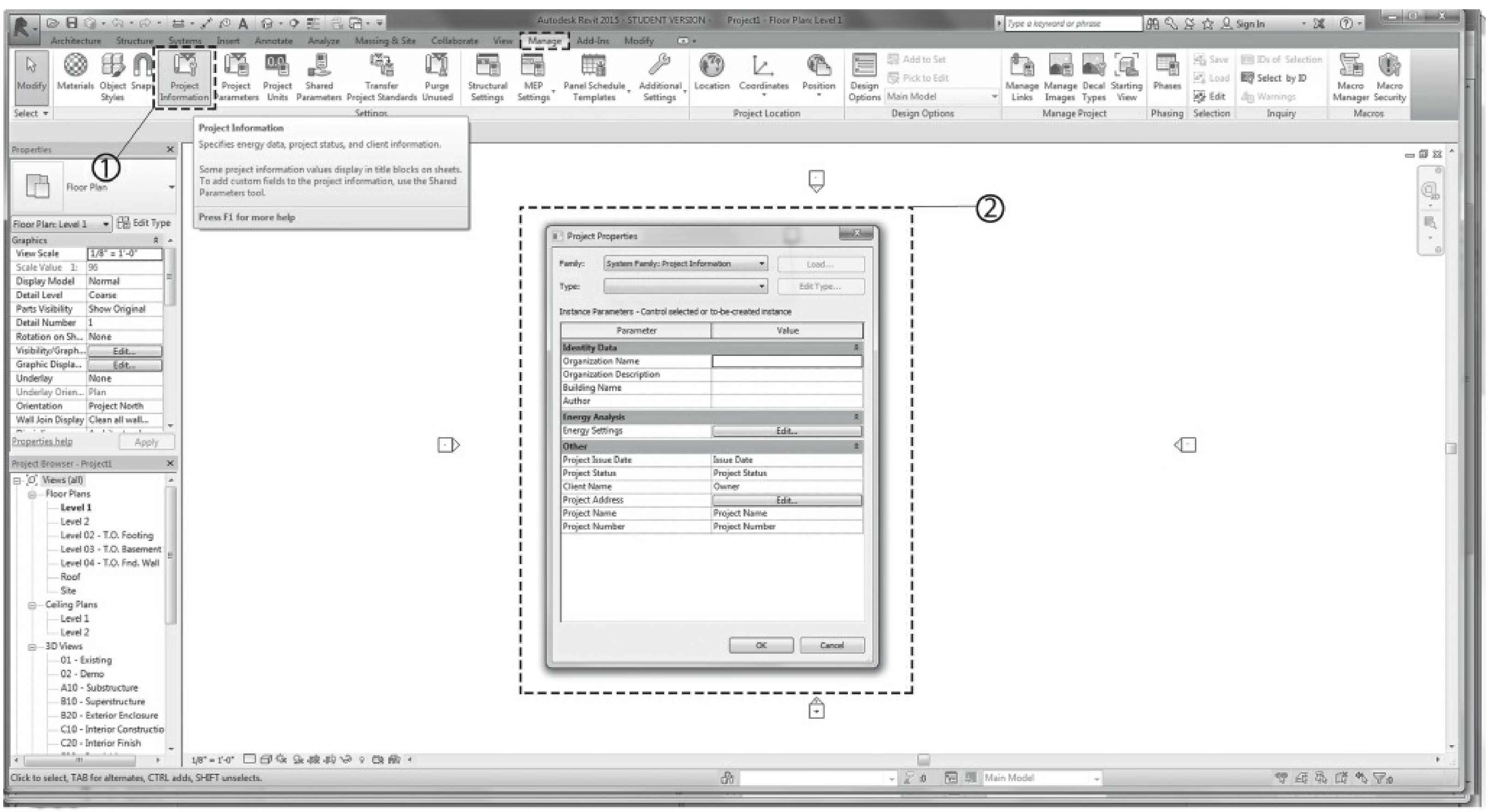


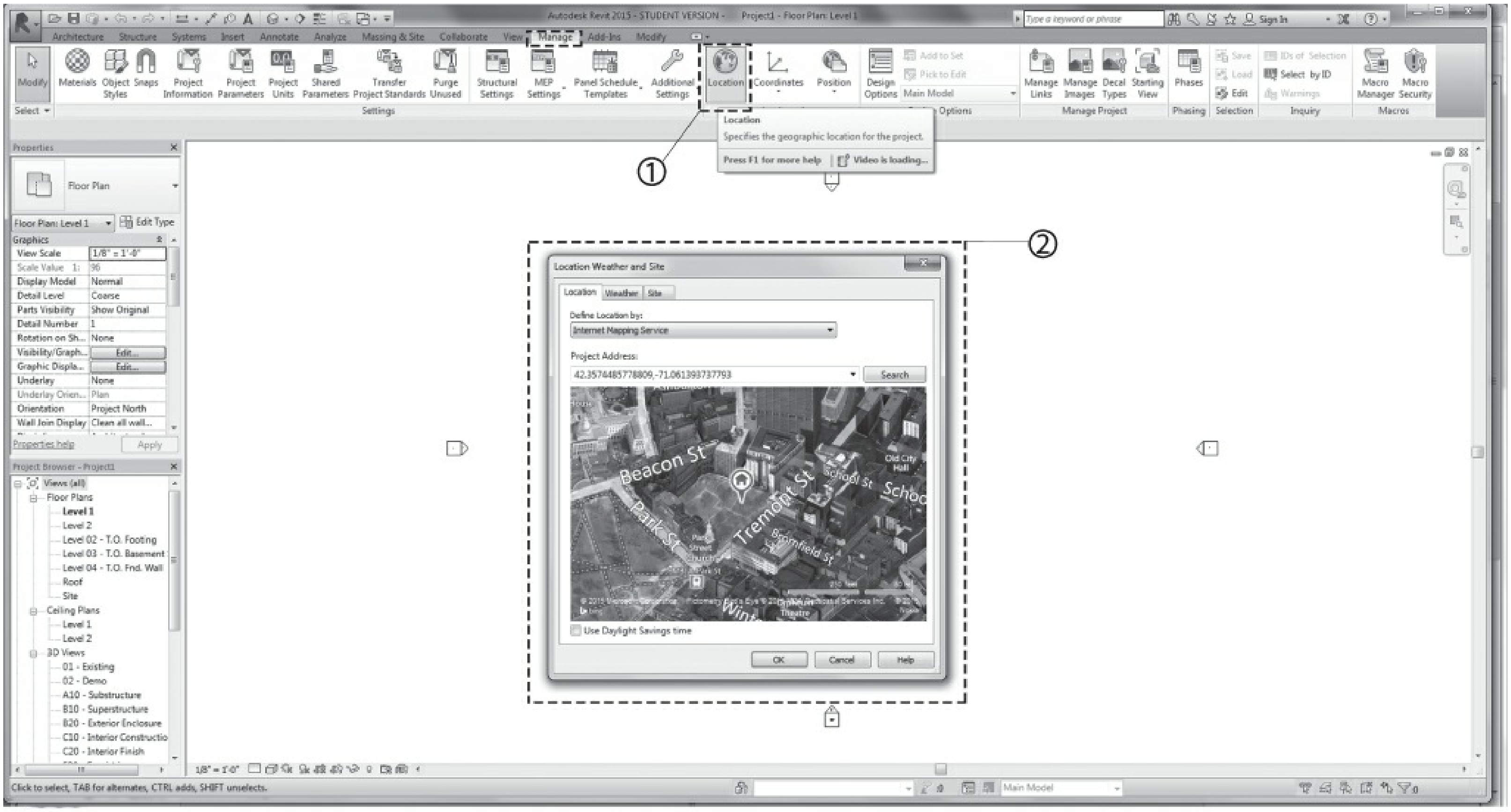
Figure 15.11 Project file window.



① Find the project information tab under the manage tab in order define your project information

② Define project, name address, project status under the project properties window

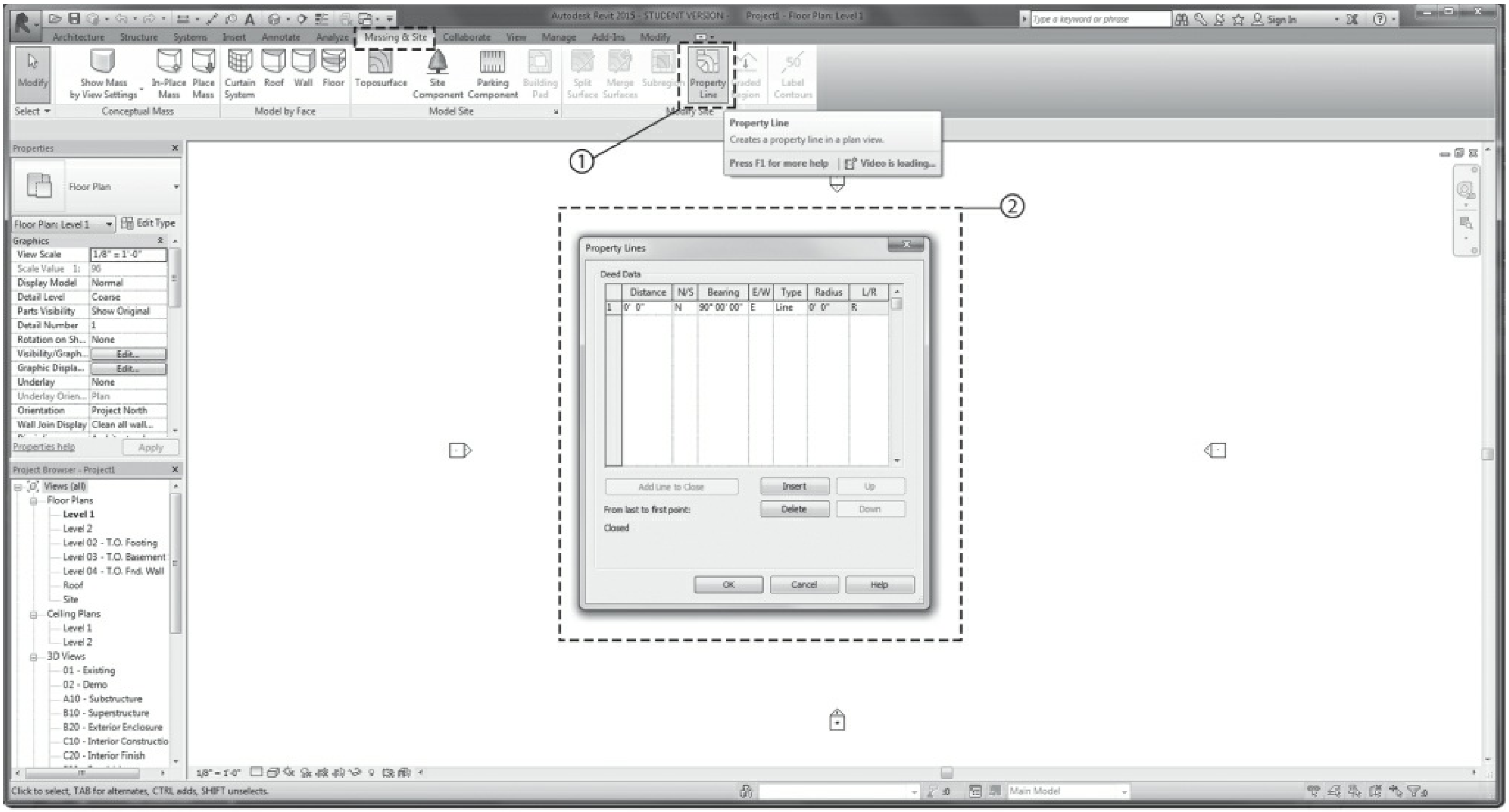
Figure 15.12 Project information.



①Find the location tab under the manage tab in order define the location of the project
②Define the location of the project address by typing project address

[Figure 15.13](#) Locating the project.

We now begin to work on the site! We will begin by going to the massing and site tab. Begin to draw the site using the civil engineer's survey of the property, which can be transferred to your drawing from the civil engineer CAD drawing by tracing over it or starting from scratch. See [Figure 15.14](#), which shows the start of a site plan by determining the bearing from scratch. The property lines will start with the bottom left corner of the site (site datum) and each property line counterclockwise. The property lines must close. See [Figure 15.15](#). If the property does not close, there may be an error in your drawings when you translated the information. The property lines are not always north…south or east…west, and each leg of the property is expressed only in feet and decimal equivalents of parts of a foot and never in inches. Most residences are drawn at a scale of 1/8″ = 1′…0″; however, an even smaller scale might be needed for larger sites. Depending on the size and shape of the site, you may need to check all the drawings to be placed on the sheet and on the module of the sheet.



1 Find the property line command under the massing and site tab.

2 Under Property Lines window you can enter the bearings to create your site.

Figure 15.14 Site plan—property lines.

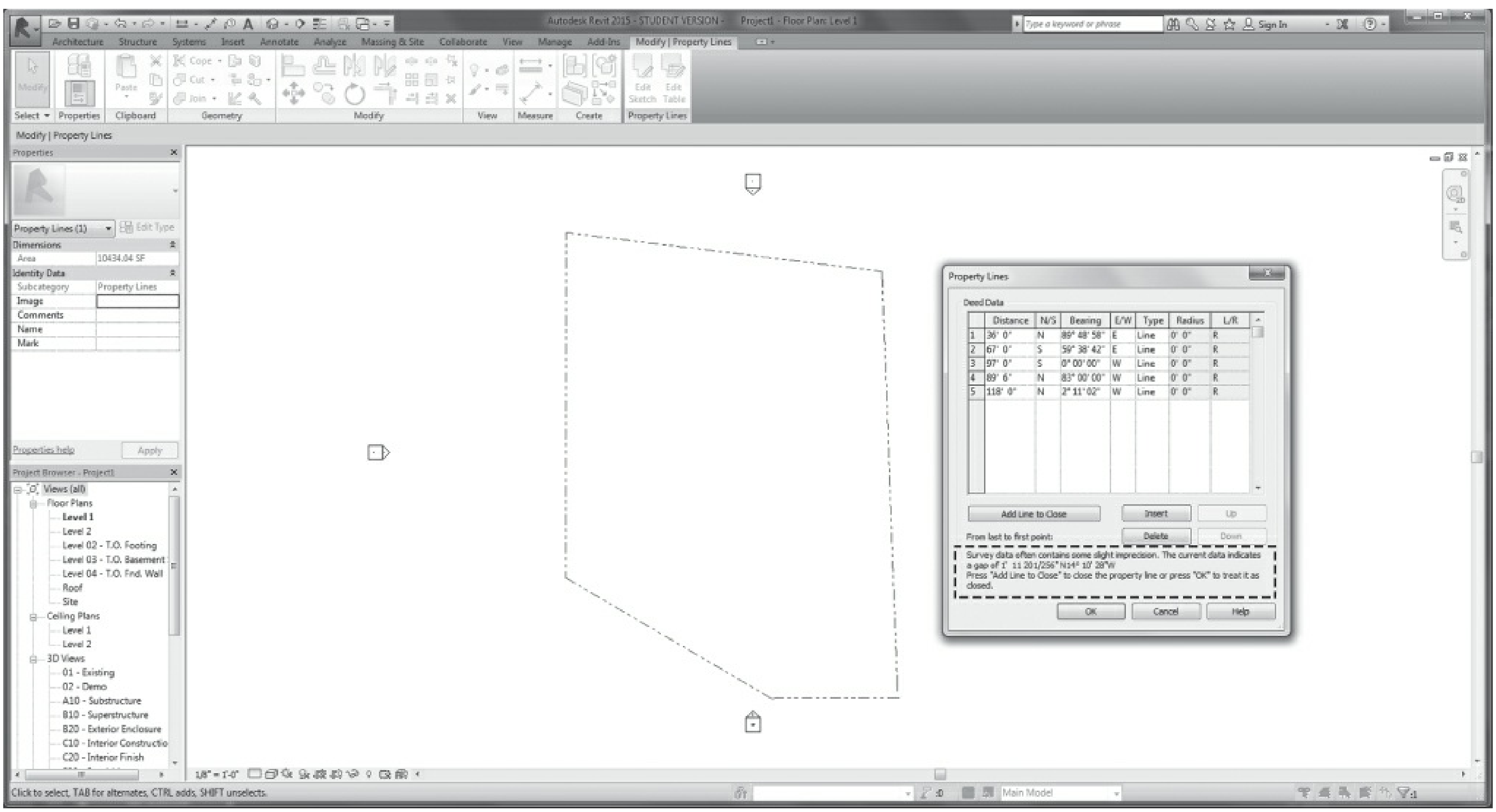


Figure 15.15 Site plan—property line not closing.

Project north and true north have to be determined the importance of true north comes

when designing your building but when creating your working documents your north has to be set to project north. These two can be interchanged under the properties tab. See Figure 15.16. Remember that your true north will also be associated with your property line bearings. You can link your floor plan to your site plan, and both will correspond and share the correct information associated with true north and the position of your building on the site.

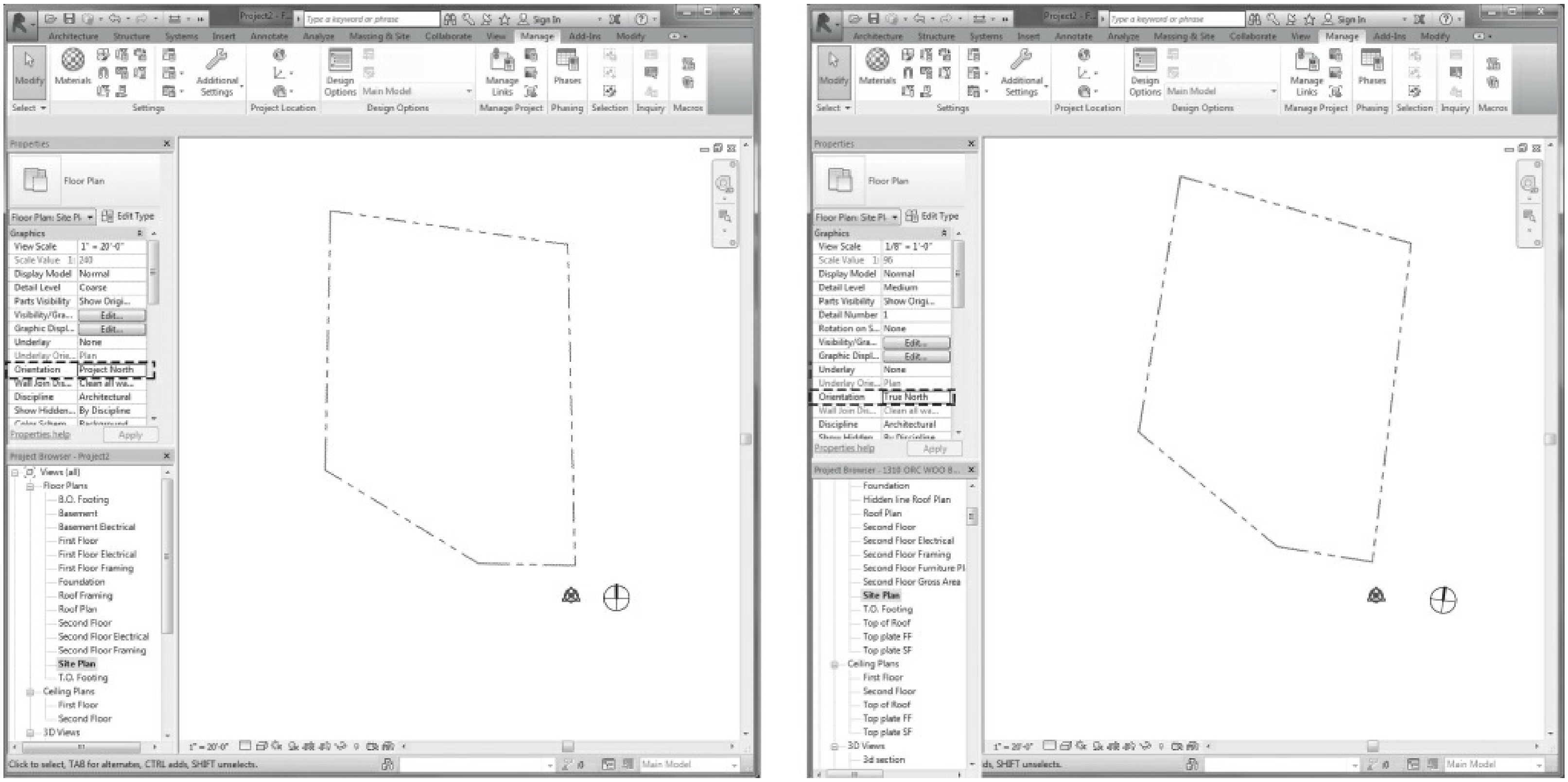


Figure 15.16 Site plan—true north vs. project north.

Floor Plan

Preparing construction documents must always begin with verifying patterns used by the designer—modules that are used to design the building and/or shapes that are unique to this particular grid is called Field Theory. The designer may be using the patterns in a different way than you might understand. Two typical examples of a field are shown—the Iowa field and one on the golden mean—in Figure 15.17. Review the standards that are used for the floor plan and not those that are already included on the computer.

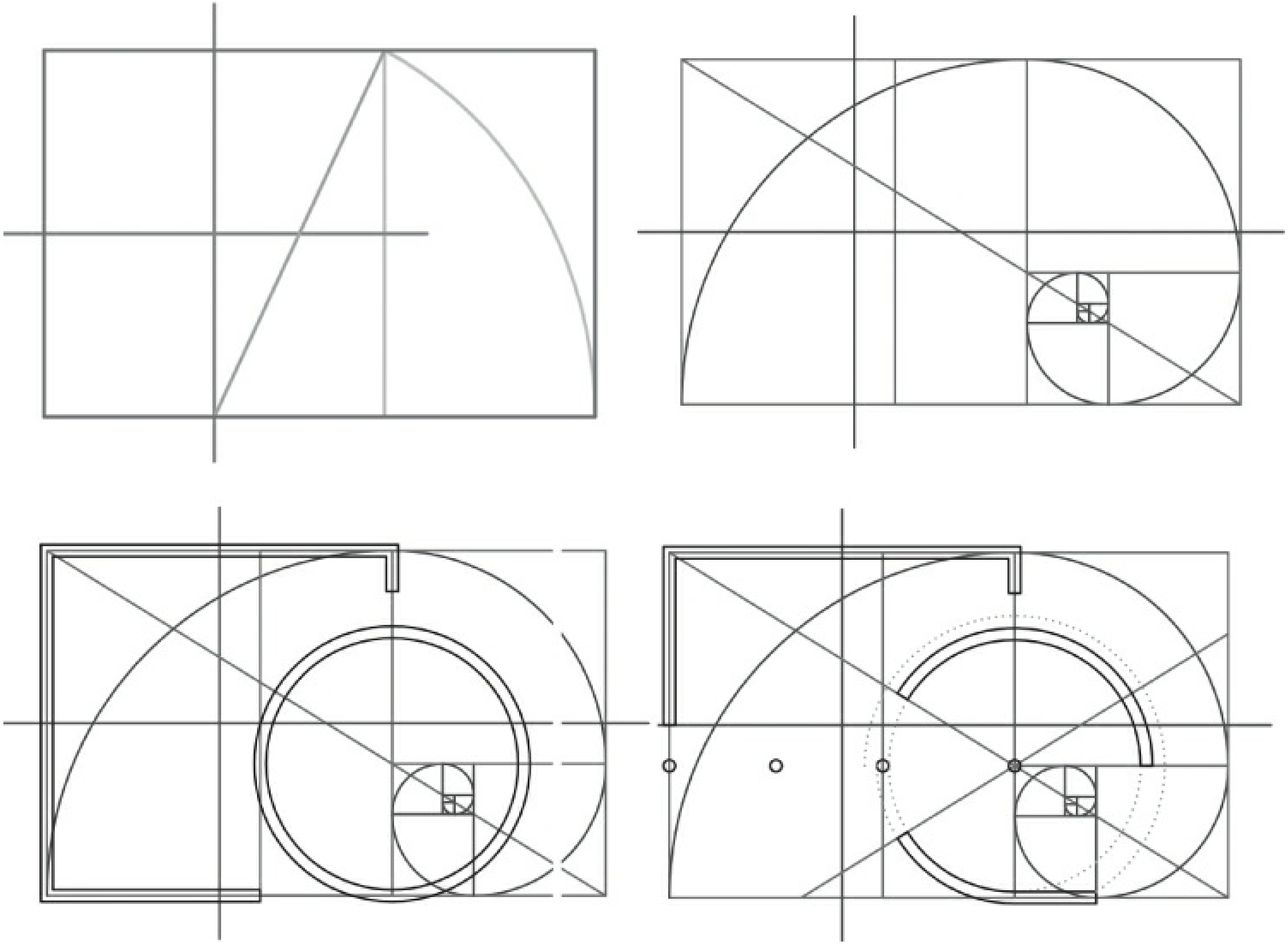


Figure 15.17 Golden mean field.

Before you begin to draw a floor plan on Revit you must make sure that your project template contains all the information required for the project. First, make sure that you have updated all of the standard annotations to comply with the architectural standards. Next, make sure your template contains all of the families you will need for your project. Remember when you are drawing a wall, you will not just be drawing two simple lines but you will be drawing an actual wall; therefore, make sure to chose the correct walls. See Figure 15.18, which shows different walls.

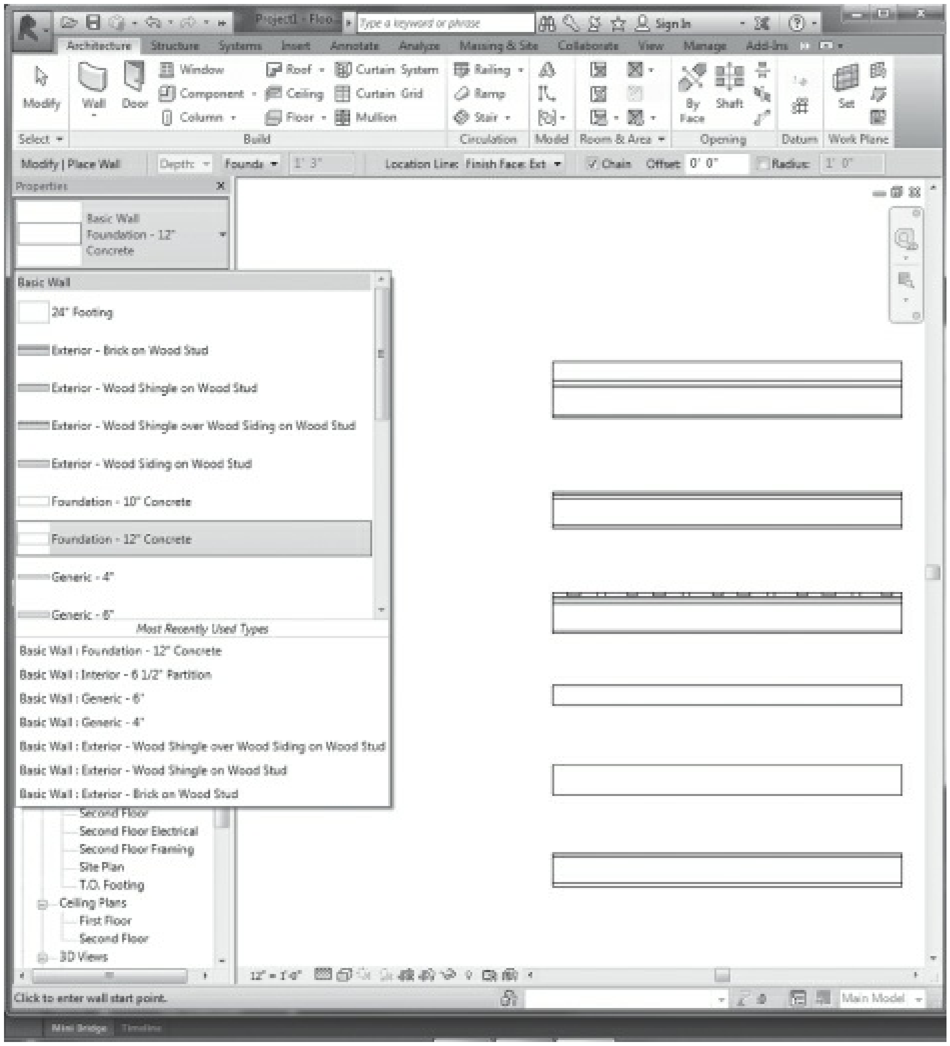
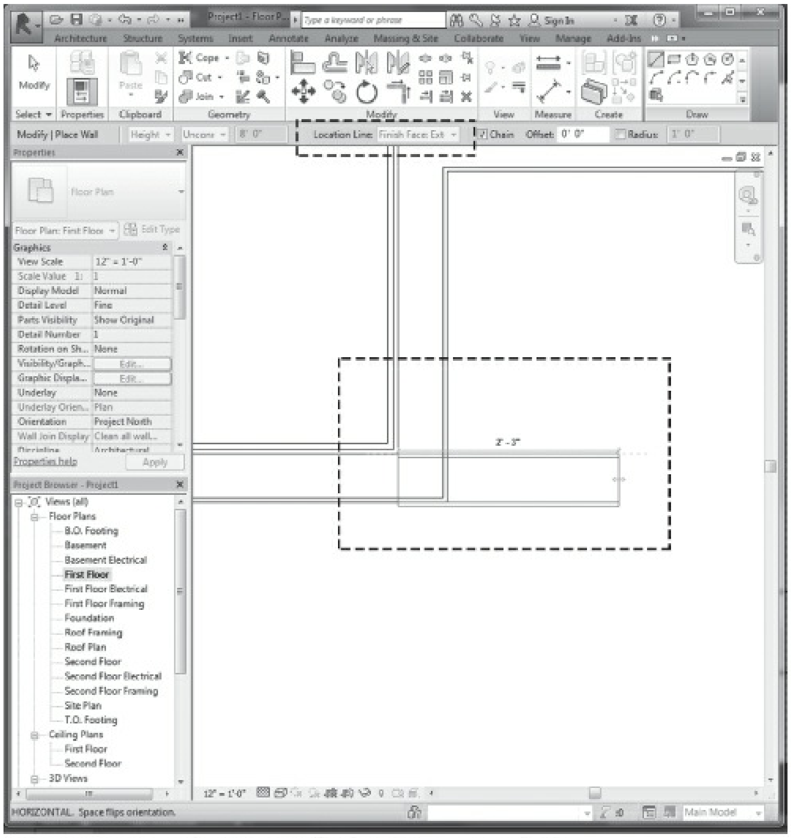


Figure 15.18 Types of walls in Revit.

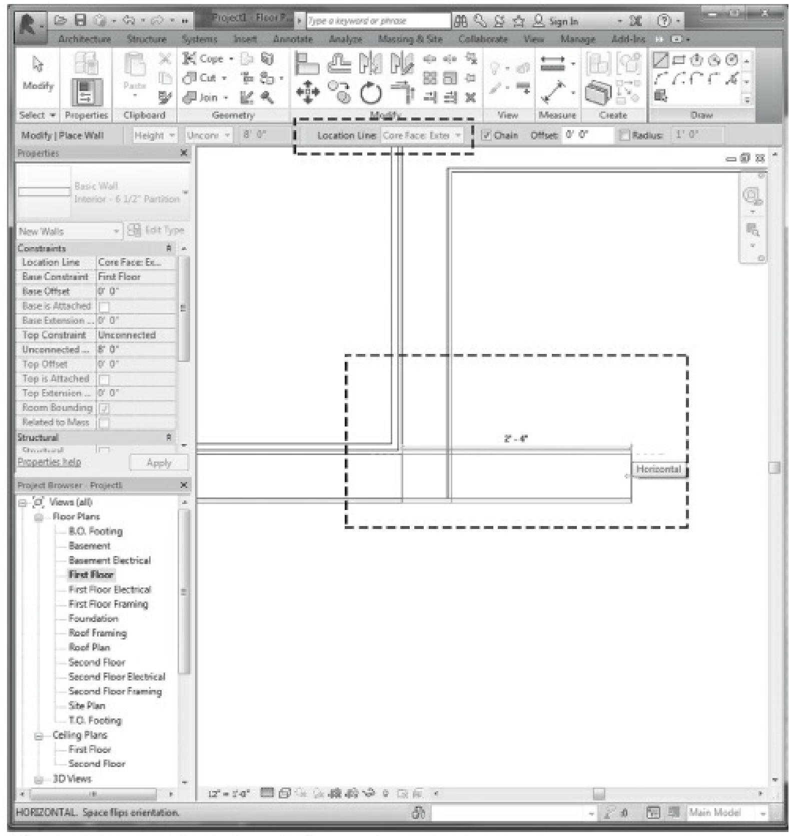
Construct the perimeter of the floor plan, again noting that your exterior walls will be different from your interior walls; therefore, you must start with the perimeter of the building and then work on the interior walls. If the plan was drawn during the design stage, your task will be to validate its size against other drawings that are available to you, such as the site plan, elevation, and building section. If the floor plan was drawn during the design phase, but Revit was not used, the technical drafter must start from scratch, as Revit drawings require a greater amount of information describing the total wall. This is called a "Family," which includes all aspects of the ingredients of a floor plan. Therefore, the walls will include in a wood‐framed structure the size, shape, and quality of the studs; a description of the covering used on the outside; and that which is used on the interior such as drywall. The information includes all aspects of the engineering, the type of building wrap which will include such items as the density, and its ability to allow what percentage of humidity at will allowed to penetrate and so on must be understood way up front. This is why Revit is often referred to as a front‐loading program, and the information and takes much more time than previous drawings, drawn on programs such as AutoCAD.

Use the proper indication for wood, steel, masonry, and the correct standard for indicating composites. If at any time you are unable to do any of the above and it is asked of you, refer to the proper chapter in this book. Be sure to check your wall type and the correct

application of wall for its condition as seen in figure 15.19.



Incorrect location line. (Finish face exterior)



Correct location line. (Core face exterior)

Figure 15.19 Checking your work.

Imagine the floor plan, but be sure to leave an ample amount of space around the perimeter of the exterior walls and the first dimension line for detail references, section lines, partial section symbols, and even structural notations and notes. Be selective for dimensions on the interior. If any dimension is not done correctly, the building might not be at right angles as desired. Chapter 8 will explain the problems that may occur.

Elevation

Please note that your elevation as well as the section will be drawn automatically as you add more information to your drawing.

Provide proper title and scale as demonstrated in figure 15.20.

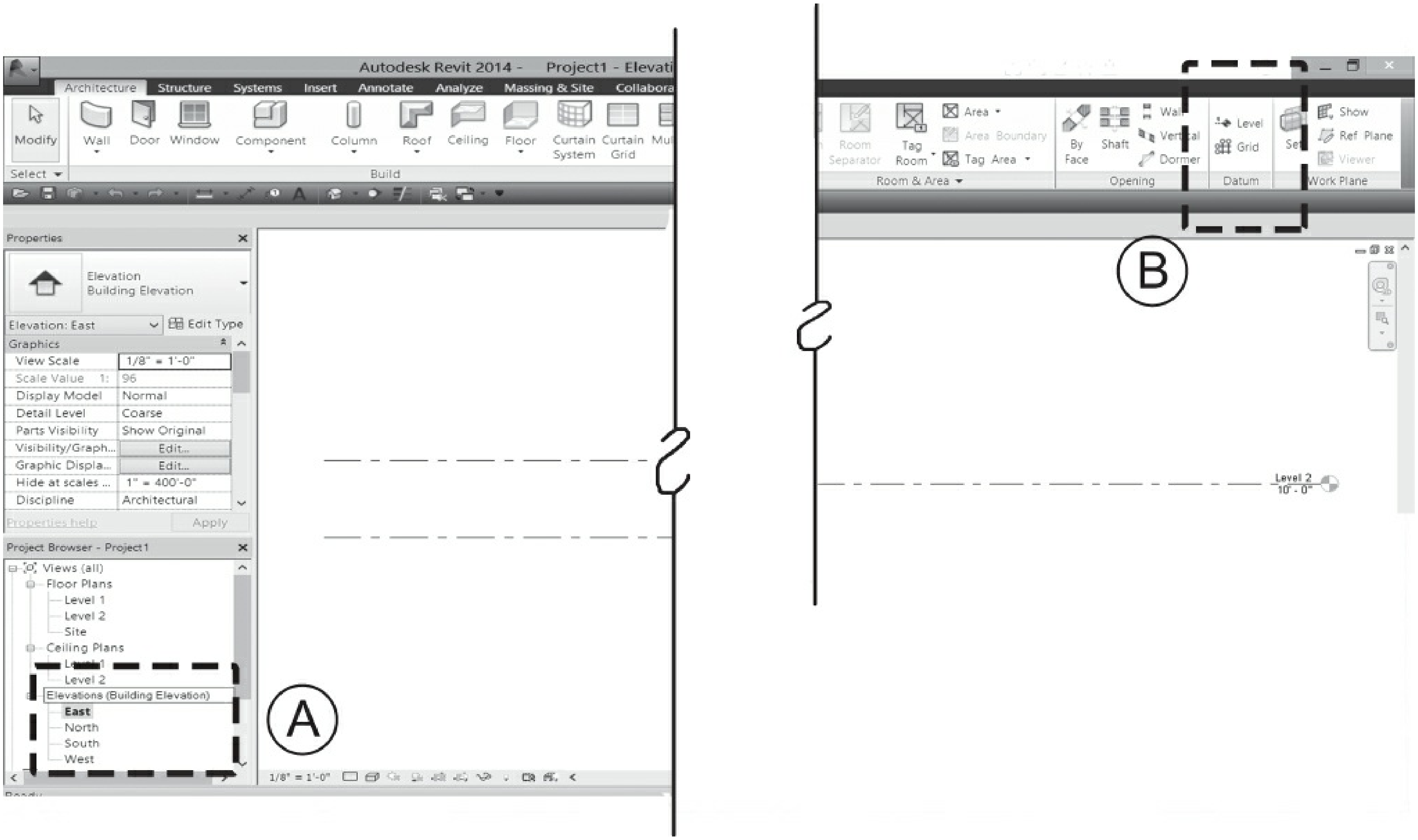


Figure 15.20 Defining datums in project.

Building Section

The preparation for drafting a building section begins with verifying the standard. Next, verify the size of the structure the materials to be used. The single most important documents to check are the structural engineer's drawings, as these will be used to start the building section.

In some offices, the drawing is almost complete with noting, dimensioning and the necessary titles. While others draw the configuration of the building immediately adjacent to the section, and some item on the inside of the building section such as columns at support the structure vertical connectors such as stairs. The item most forgotten by the beginner are framing members that come toward the observer, such as floor joists and ceiling joists. See Figure 15.21.

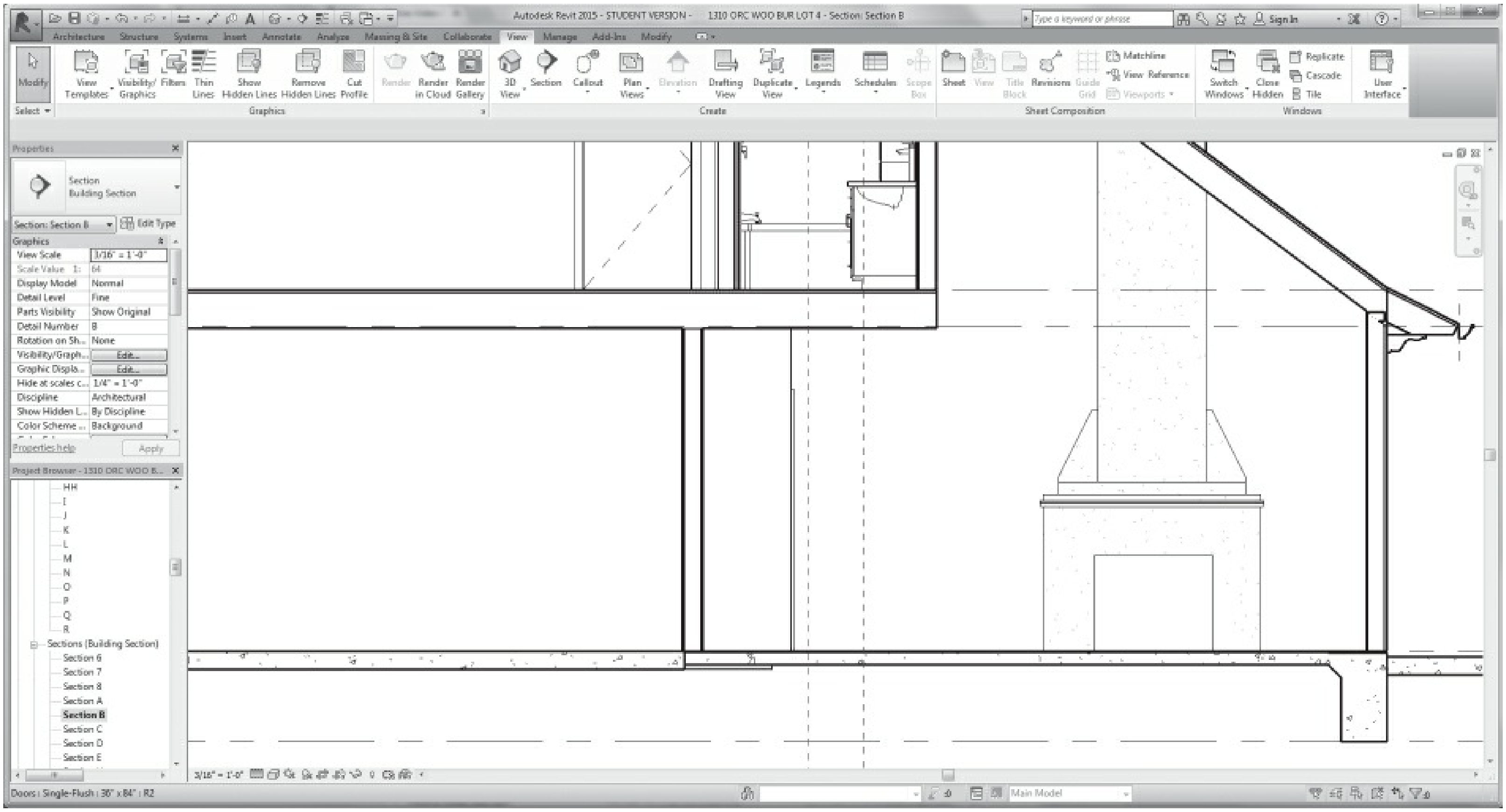


Figure 15.21 Section—cutting plane.

In Revit you start by cutting a section through your drawing. You can set up how much of that section should cut through if you don't want to show a lot of information. You must plan where you will cut your section. See Figure 15.22. You may find that there is a lot of information on your section that you don't need. You can turn off the information you don't want to see. See Figure 15.23. You can also set the level of detail you want your drawing to show, and all of these can be saved as a view template; therefore, every time you are working on your sections, they will all show the same amount of information that you previously set. As mentioned before, the most forgotten items to be shown by a beginner are the framing members. You can show these framing members by going to your annotate tab and choose them under the components tab. See Figure 15.24. You can now start adding annotations by going to the annotation text tab. See Figure 15.25.

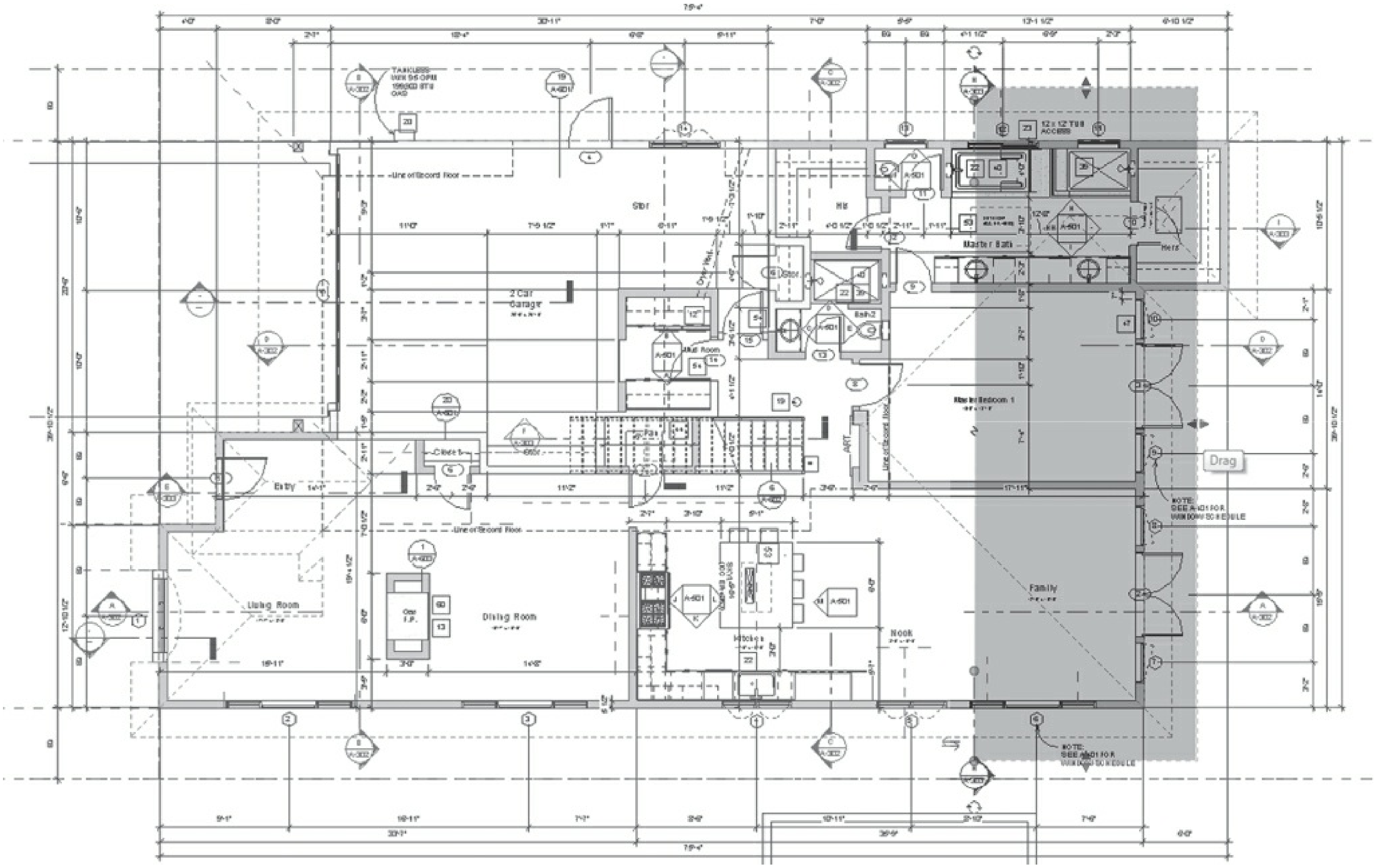
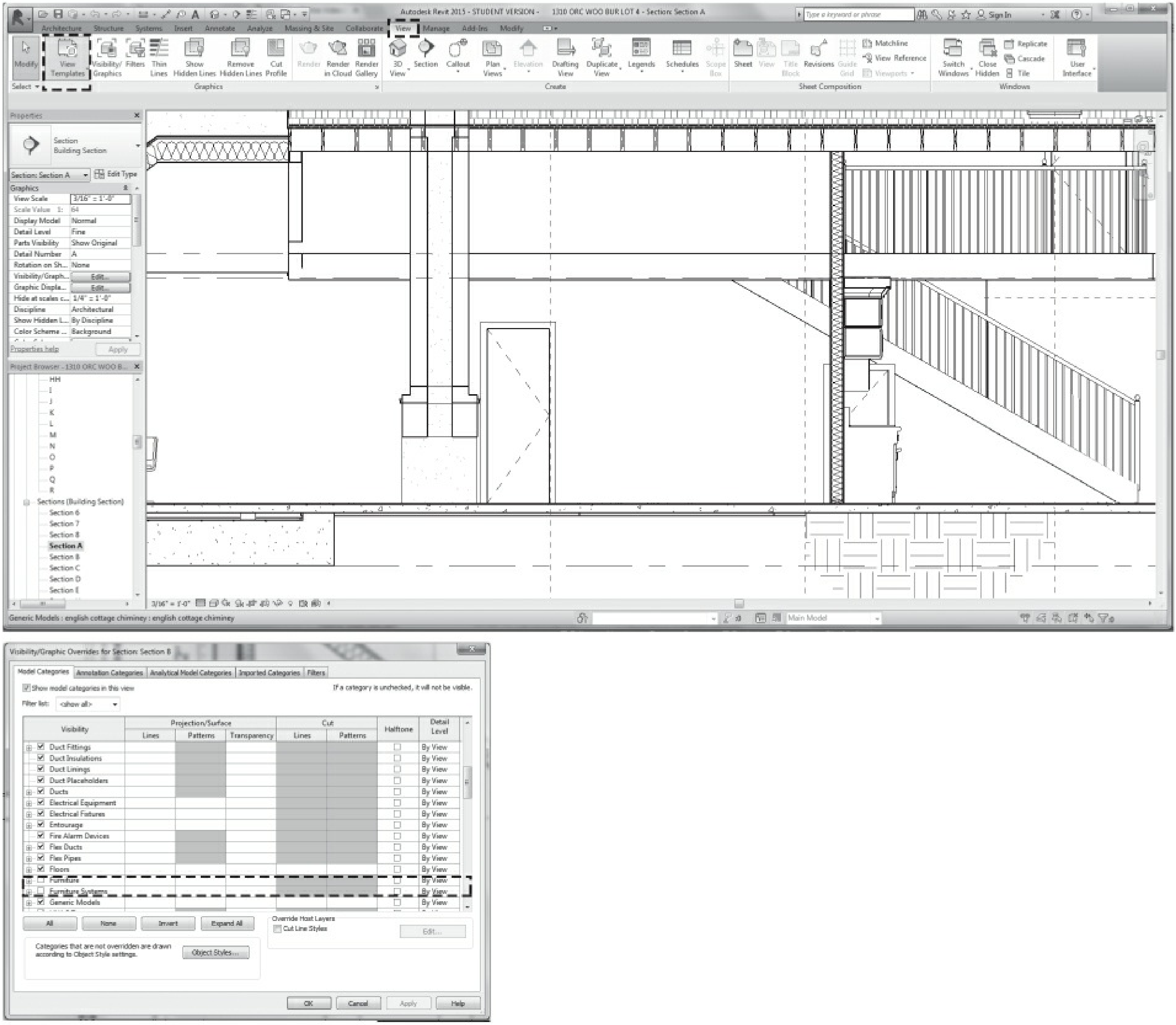
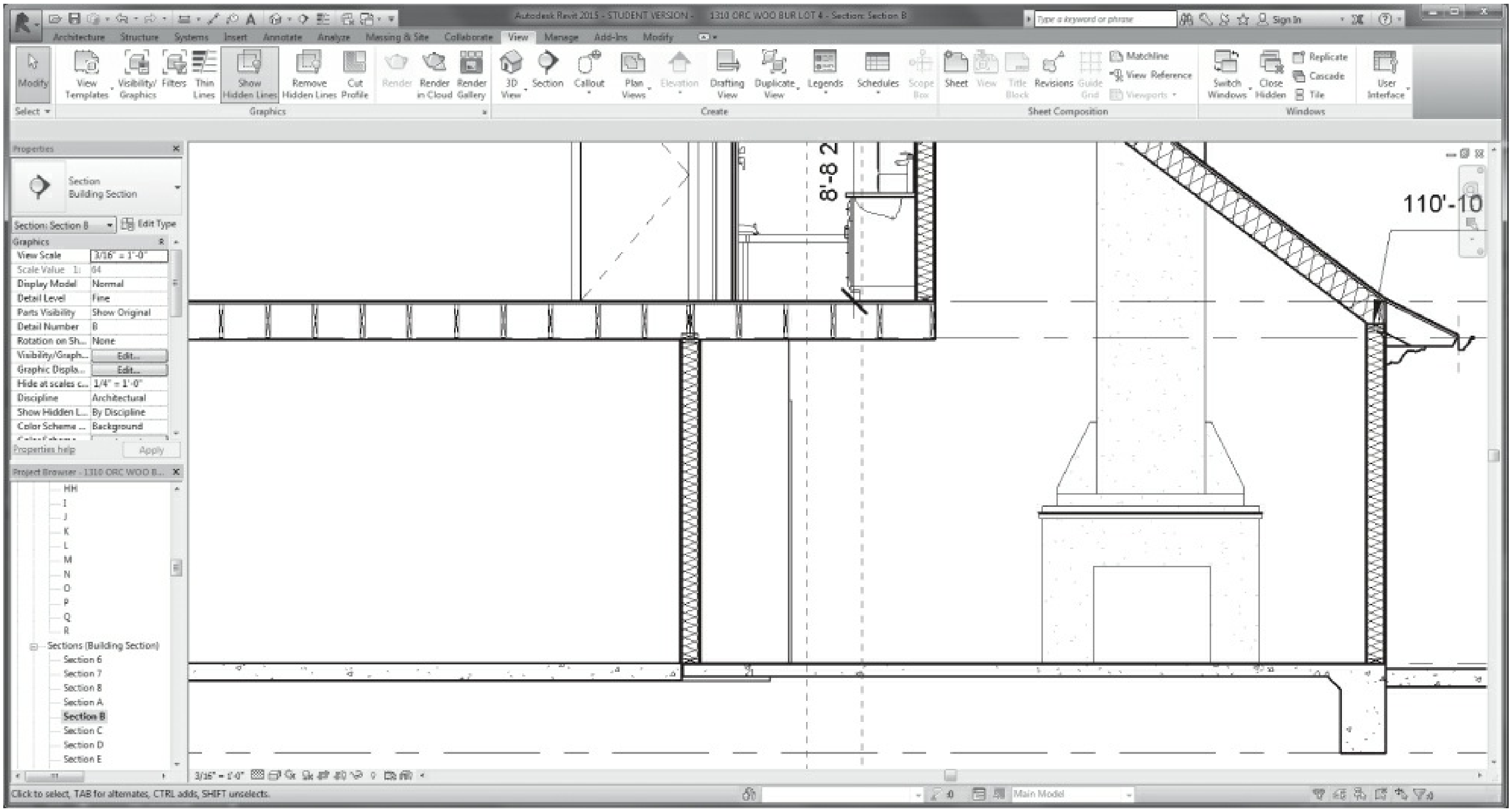


Figure 15.22 Section—determining cutting plane.

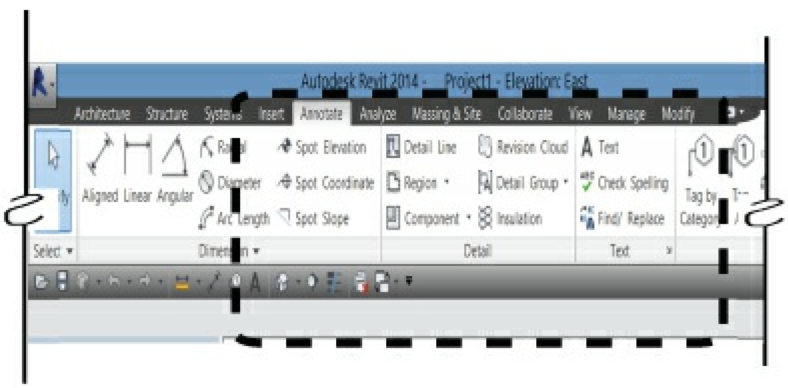


Hidding elements under visibility window

Figure 15.23 Section—cleaning up your section.



[Figure 15.24](#) Section—showing framing members.



[Figure 15.25](#) Section—annotations.

Key Terms

Building Design Suite

Building information modeling (BIM)

Revit

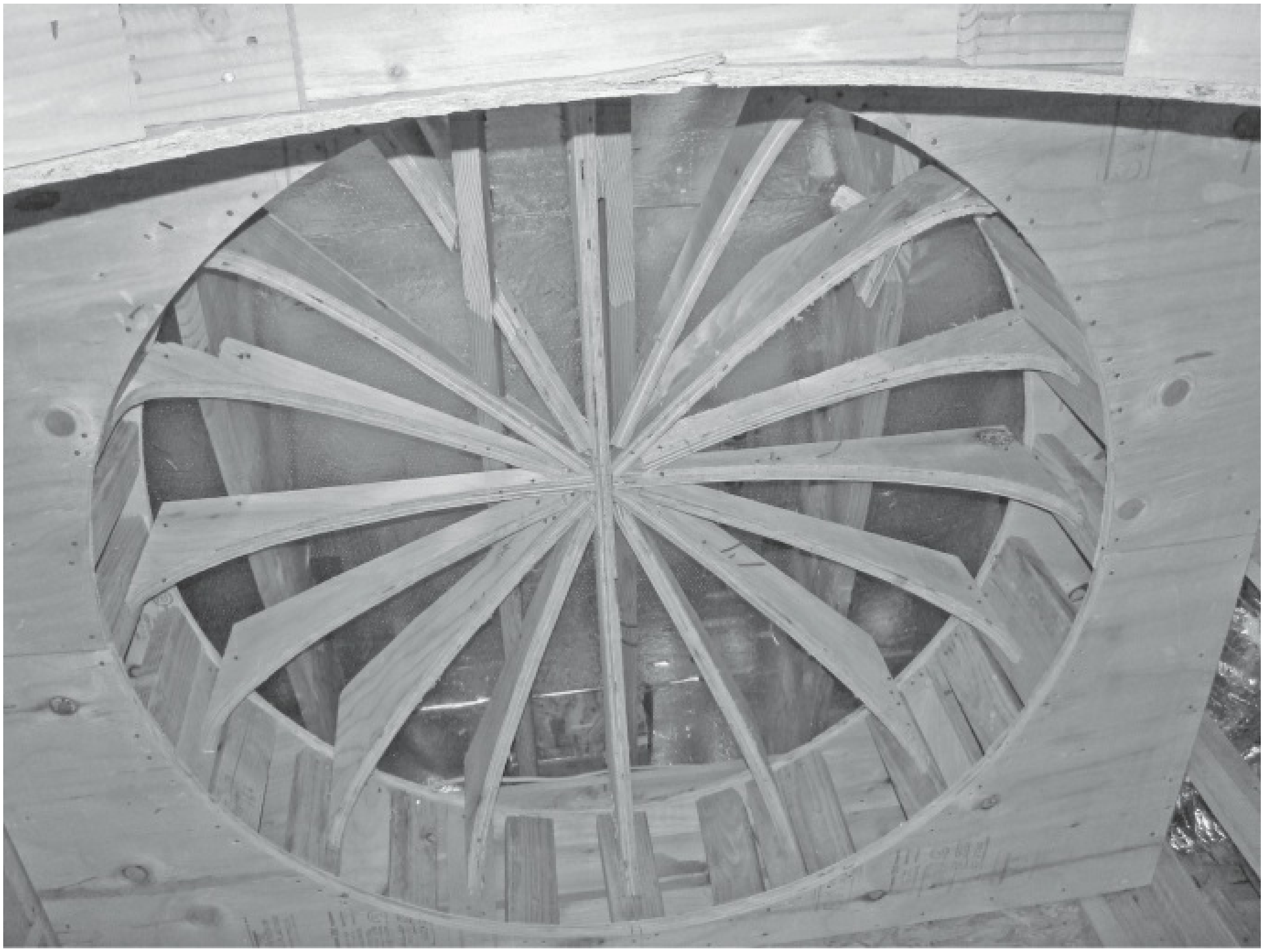
PART IV
Case Studies

As you seek a job in an architectural office, you will see many examples of construction documents of work in progress. We cannot emulate this in a textbook, but we can show a few examples of actual working drawings. These are to be used as references, not to be copied. In addition to being a violation of copyright, copying will not achieve the results you want and need. Each project is unique: among other things, codes differ, environmental conditions (such as soil conditions and proximity to salt…laden ocean air) differ, and so each structure will also differ.

Case studies are selected from technically simple tasks to somewhat complex projects that every technical drafter will be expected to perform in an office. They are based on universal and international standards, which will make your architectural education sound. You will experience dimensioning; dealing with steel, wood, and masonry; multiple floors; and front…loading the contract because of computer programs such as Revit, and so on. AutoCad and Revit will be used on the Jadyn residence, the Jakob residence, Clay Theater, and the Madison office building. The remainder of the case studies—the Blu residence, the Tylin residence.

There are six examples in this part:

Chapter 16
ONE–STORY CONVENTIONAL WOOD–FRAMED STRUCTURES



INTRODUCTION

The design purpose is to create a home that has room for growth. The site is a typical city lot in Anytown, USA, and for this example we call it the Jadyn residence. The zoning is R…1 (residential), the setbacks are 15′…0″ in the front, 5′…0″ on the sides, and 15′…0″ at the rear. Water flows to the rear in the direction of the lot's slope, and this slope opens up to a city view. See Figure 16.1.

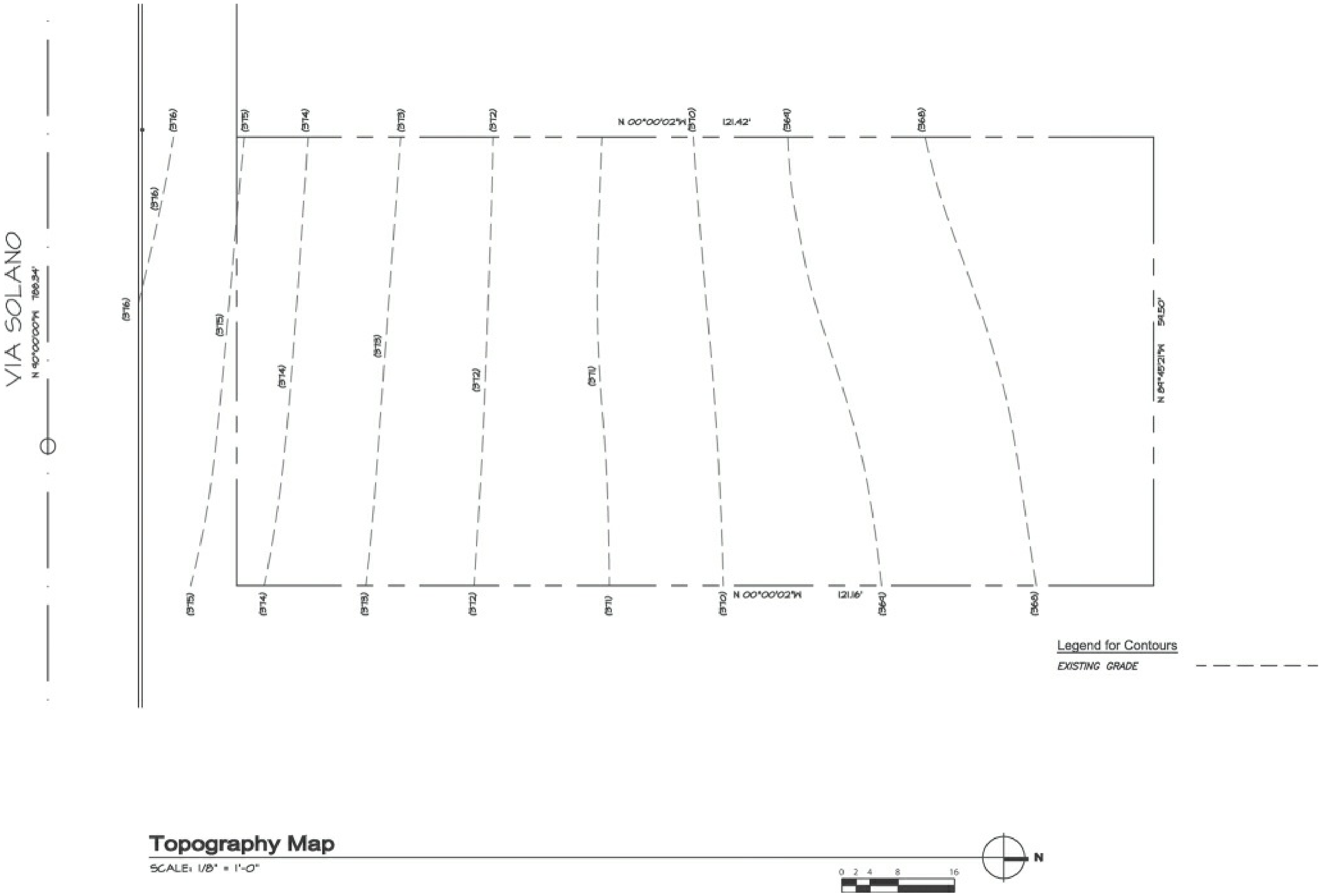


Figure 16.1 Jadyn residence site.

The Jadyn Residence

Along with the bedroom and two baths, the client requested a family room and kitchen oriented toward the view, and living room, nook, and formal dining room. The intention is that the owner will provide a second story at a later date.

Initial Schematic Studies

Using what is commonly called **bubble diagramming**, room relationships were quickly established. See Figure 16.2. The bedroom, family room, and kitchen were oriented to the rear of the lot to take advantage of the view and avoid the street noise. With the prevailing wind coming from the northwest, each of these rooms will be well ventilated. The garage was positioned perpendicular to the street. Circulation is through the center of the structure, which serves as a spline or connector to all of the rooms. Included for this example are a preliminary design development site plan (Figure 16.3), floor plan (Figure 16.4), and a couple of elevations (Figure 16.5). If this set of drawings is approved, additional preliminary drawings are developed, which may include a roof plan (Figure 16.6), a design section (Figure 16.7), and possibly a framing plan.

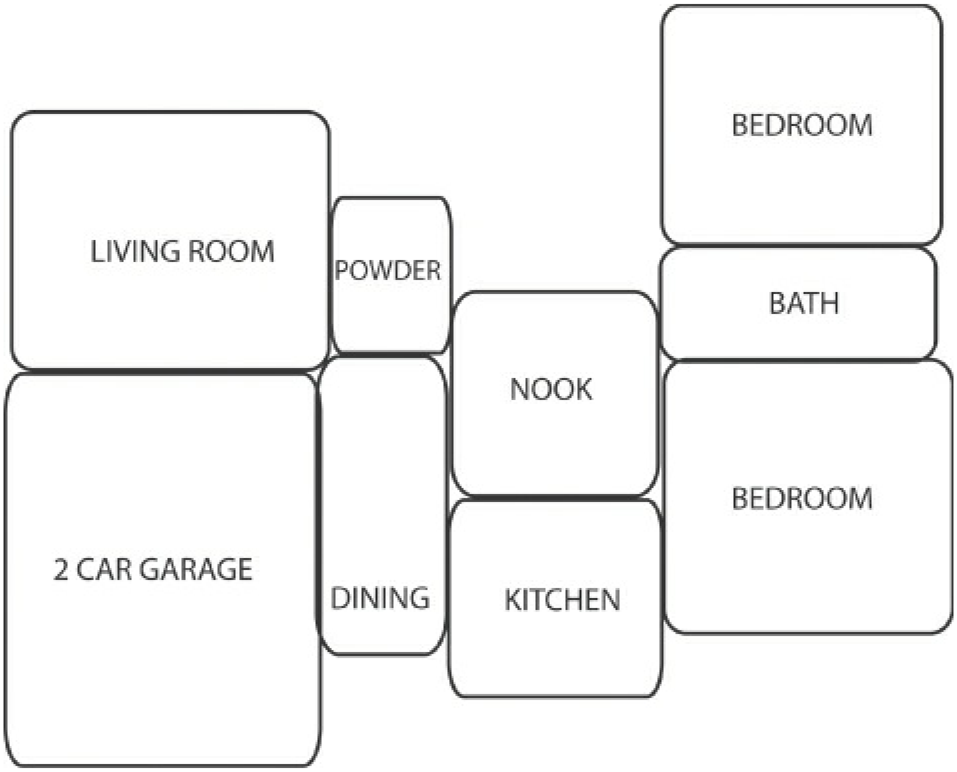


Figure 16.2 Bubble diagramming the Jadyn residence.


VIA SOLANO
N 9000'00"W 788.34'
416 South Street
Santa Monica, California
(376)
(375)
(374)
(373)
(372)
(371)
(370)
(369)
(368)
N 0000'02"W
121.42'
121.16'
371
370
369
368
N 8945'21"W 59.50'

Figure 16.3 Preliminary design development, Jadyn residence site plan.

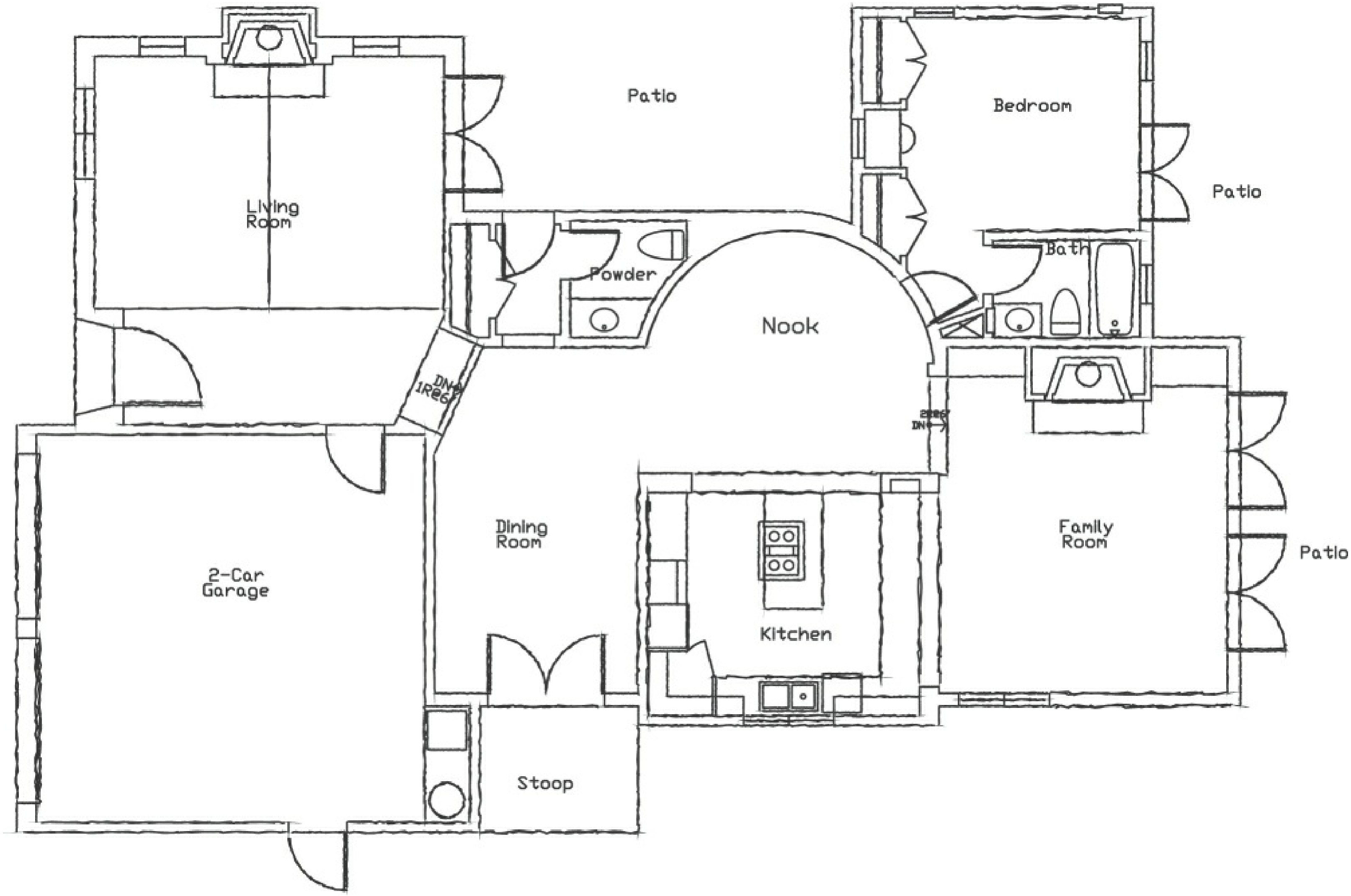


Figure 16.4 Preliminary design development, Jadyn residence floor plan.

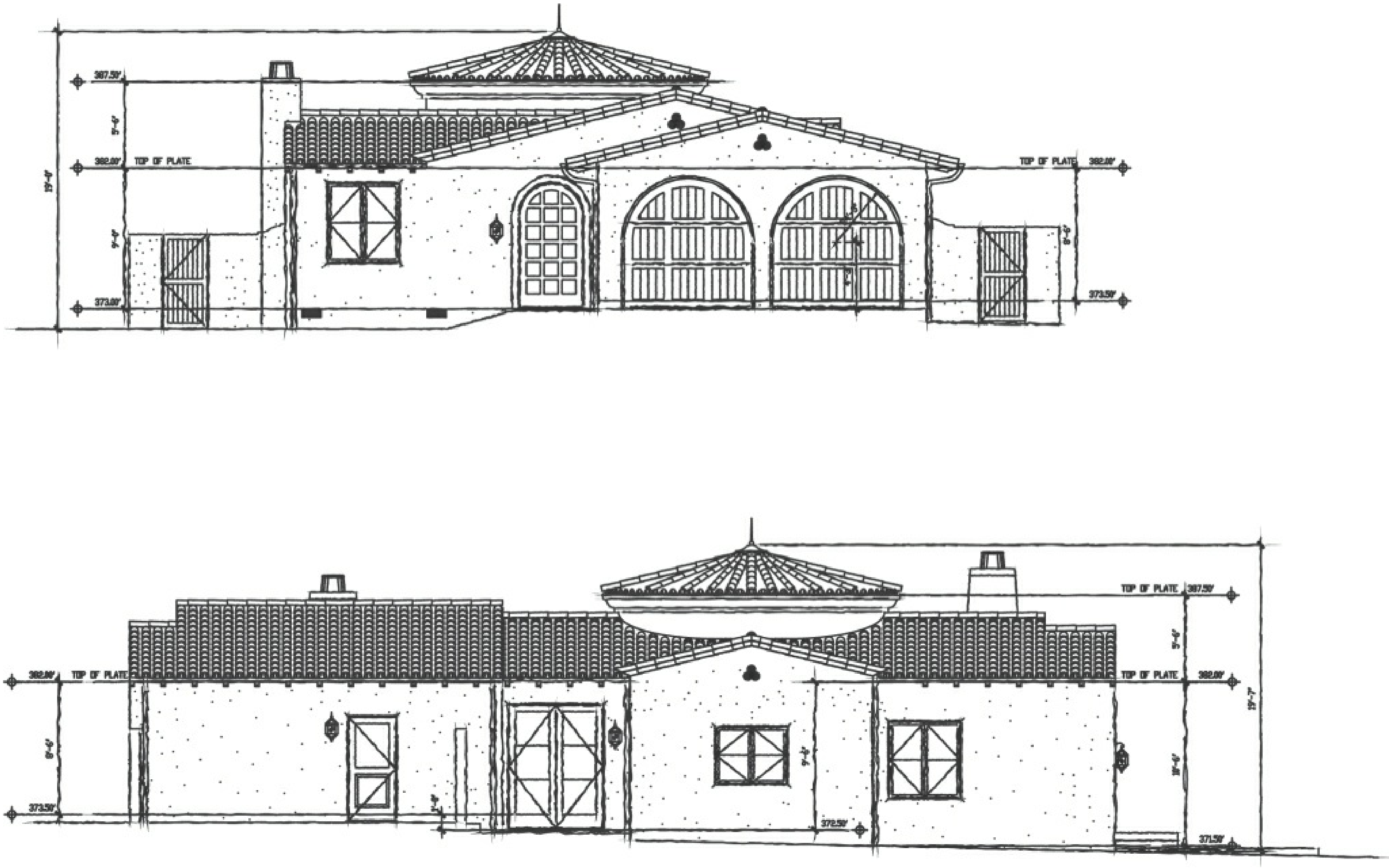


Figure 16.5 Preliminary design development, Jadyn residence elevations.

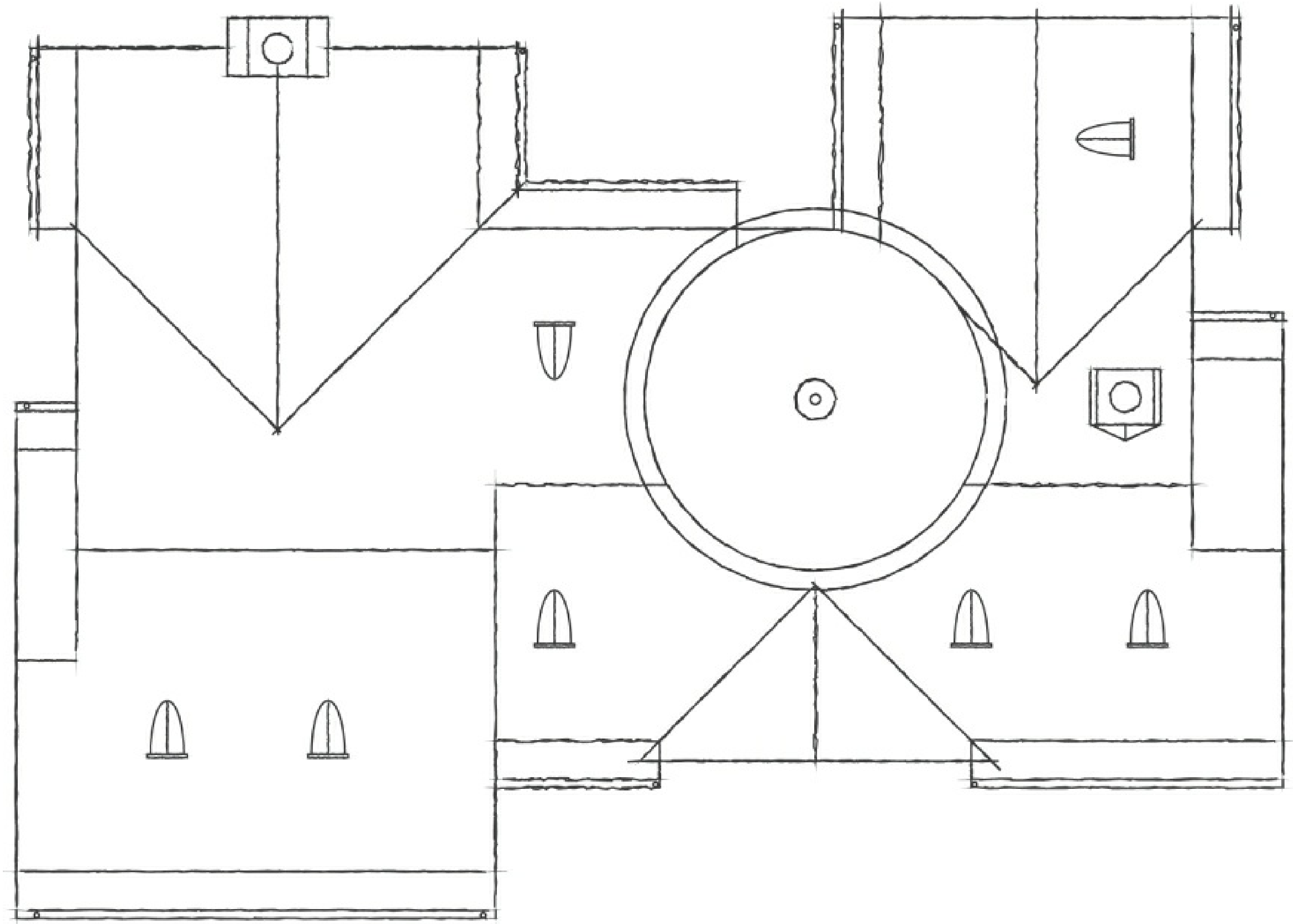


Figure 16.6 Preliminary design development, Jadyn residence roof plan.

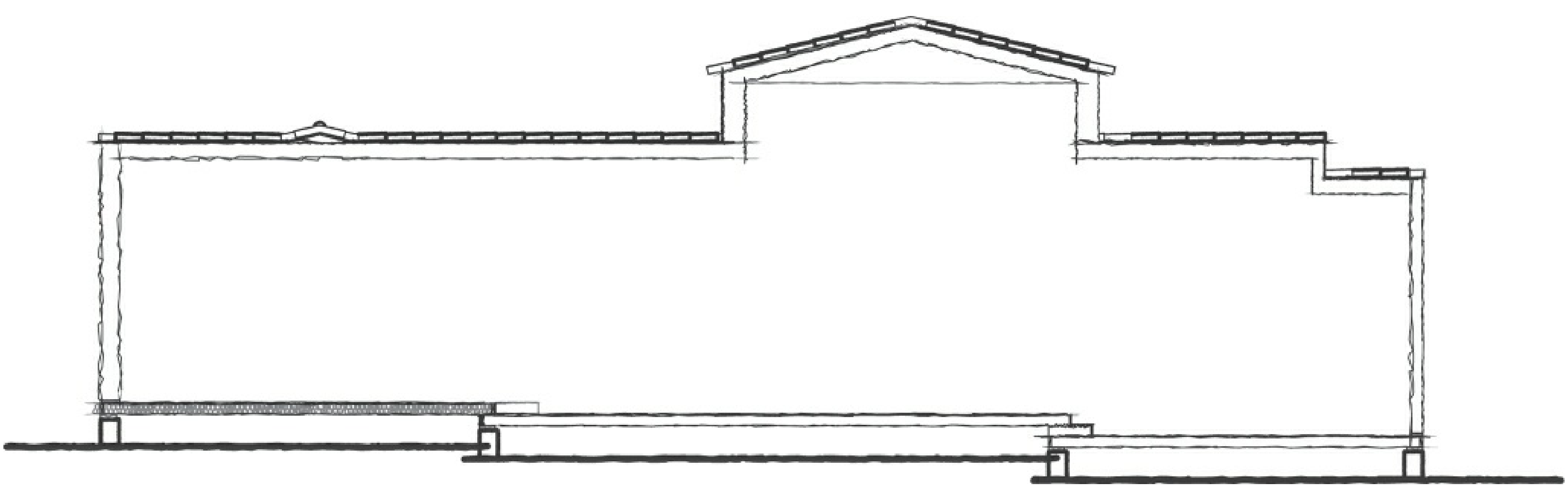


Figure 16.7 Preliminary building design section, Jadyn residence.

DESIGN AND SCHEMATIC DRAWINGS

The schematic drawings represent the culmination of many hours of designer…client decisions. The final changes chosen by the client are based on such things as financing,

size of the structure, or projected number of users. Eventually, a final design decision is made and signed, and at that point becomes the final design proposal used by the architect to develop a set of construction drawings.

The architect develops preliminary drawings in response to the client's needs. These drawings provide the basis for the formulation and incorporation of changes and new ideas. Included for this example are a site plan (Figure 16.3), floor plan (Figure 16.4), and a couple of elevations (Figure 16.5).

If this set of drawings is approved, additional preliminary drawings are conceived, which may include a roof plan (Figure 16.6), a design section (Figure 16.7), and possibly a framing plan.

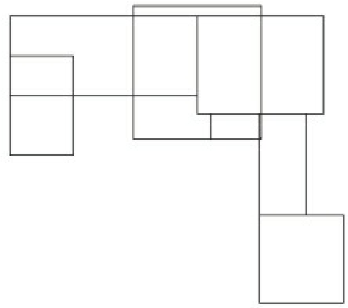
Client Changes

The preliminary floor plan plays a very important part in the development of a final configuration or shape of a structure. It gives the client time to look at and discuss some of the important family needs or to make major changes before the project progresses too far.

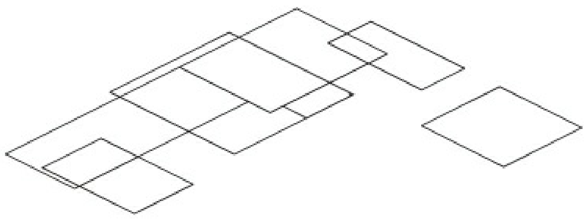
Client changes are an integral part of the design process: It is much more likely that the client will generate changes to a plan than it is to have a client fully accept the plan as first presented. It is also common for the client to order or request changes throughout the entire design process and even construction of the project.

Development of Elevations

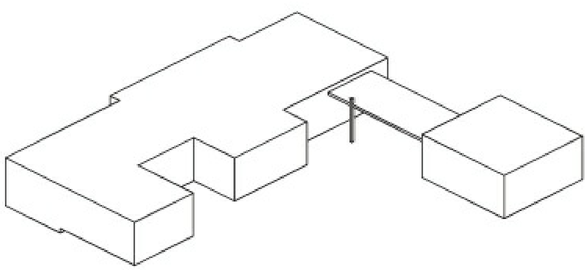
The model helps the clients to visualize how the structure will look and to comprehend the preliminary exterior elevations, as seen in Figure 16.8. In this example, a simple series of rectangular shapes were extruded; the roof was then added and features delineated to establish a three…dimensional (3…D) view or a schematic design.



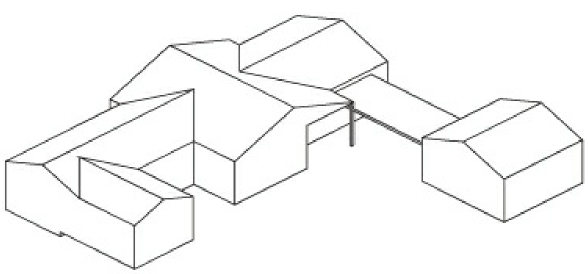
A INITIAL AUTOCAD 2-D DRAWING



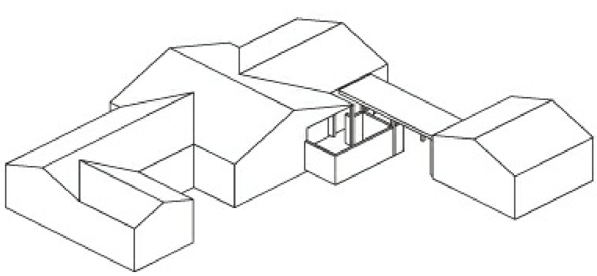
B 3-D LAYOUT READY TO EXTRUDE



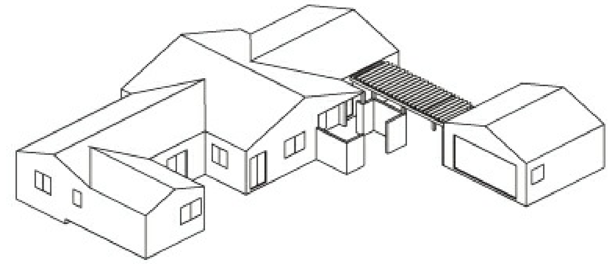
C HEIGHTS EXTRUDED



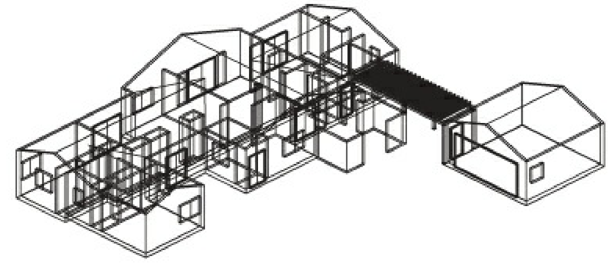
D ROOF ADDED



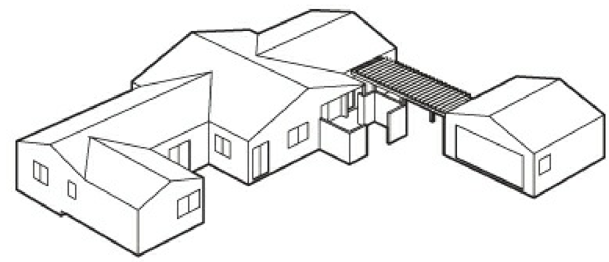
E ADDITION OF SITE FEATURES



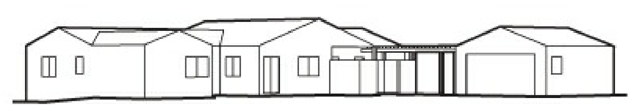
F FURTHER ARTICULATION OF FORM



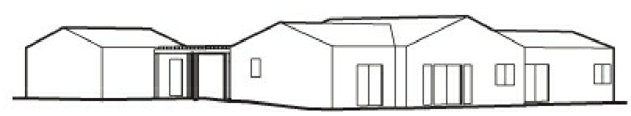
G WIRE OF MASSING MODEL



H HIDDEN OF MASSING MODEL



I PICTORIAL SKETCH



J AREA SKETCHES

Figure 16.8 Evolution of a 2…D to a 3…D sketch.

EVOLUTION OF THE WORKING DRAWINGS

In Chapters 2 and 3, the case studies are tracked stage by stage within the confines of the specific topic. Examine each example for the specific type of construction. Here, we cover a general pattern for evolution of the working drawings.

Other Preliminary Drawings

Other preliminary drawings may be done by the design and structural associates, making the CAD drafter's task easier. Such drawings might include a preliminary foundation plan, a revised preliminary building section and roof plans, and a revised framing system.

Cartoon of the Project

A **cartoon sheet** format, or **mock set** as it is called in some regions, is a reduced replica of the distribution of the drawings on each of the working drawing sheets, drawn on an 8½″ × 11″ sheet of paper. These can be accomplished by substituting rectangles in place of the actual drawings, as shown in Figures 16.9 and 16.10.

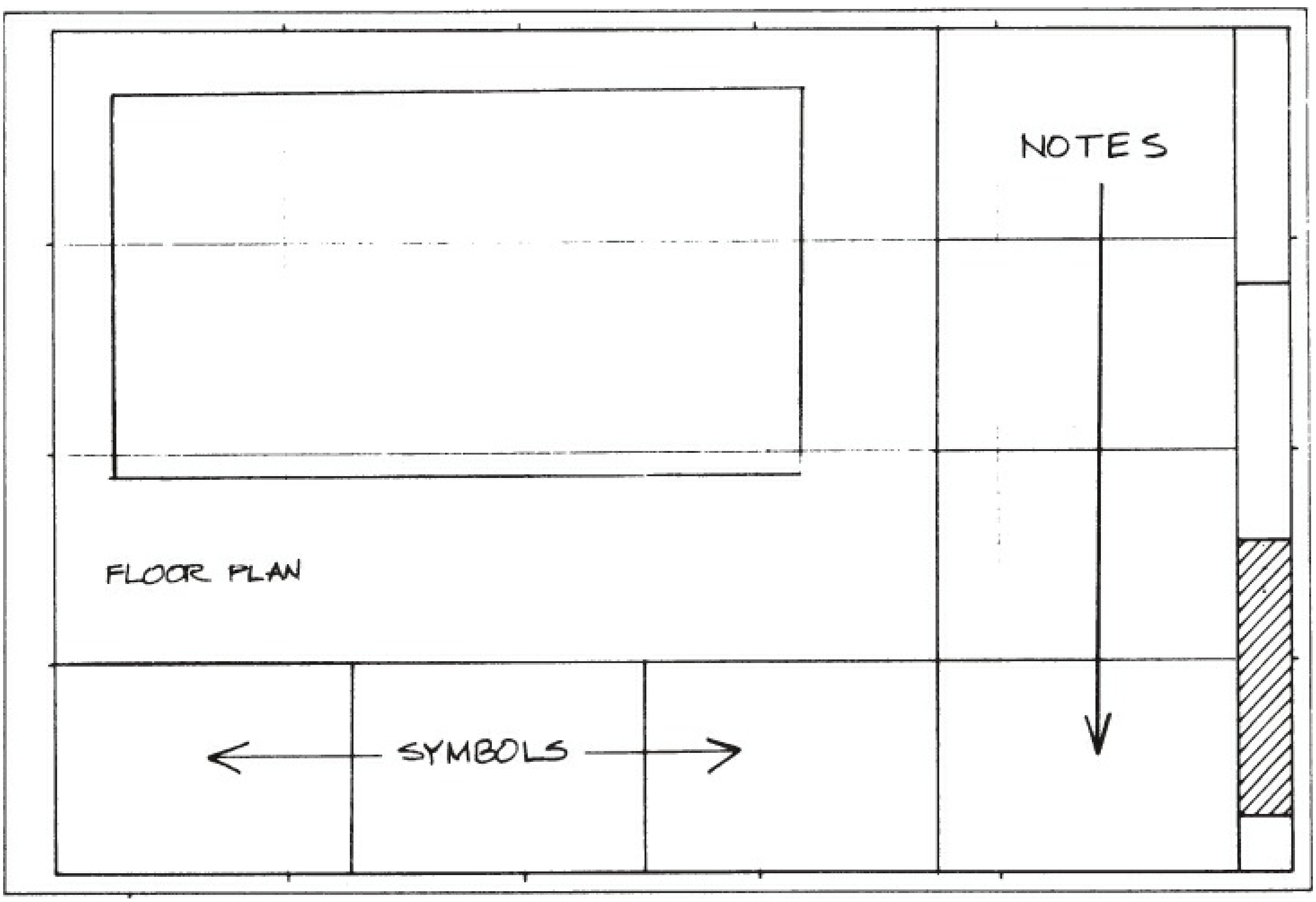


Figure 16.9 Cartoon of floor…plan sheet.

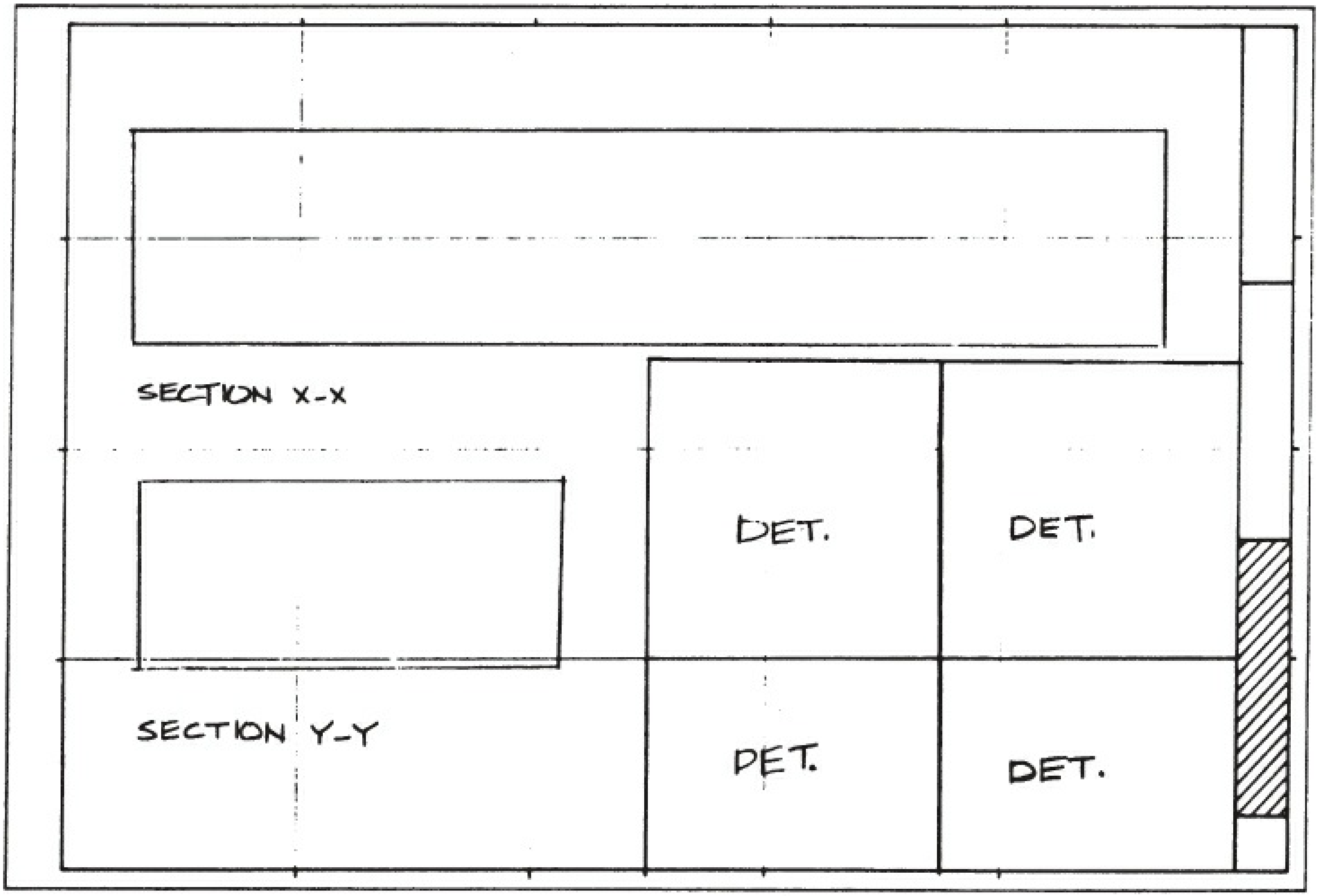


Figure 16.10 Cartoon of section sheet.

Procedure for Single or Multiple Working Drawing Sheets

After looking at the cartoon of each sheet, the project architect must determine how these working drawing sheets will evolve. Will a single drafter take on the responsibility for each single sheet, or will a number of drafters be working on it? Can parts of a single sheet be delegated to two or three individuals, drawn on separate sheets, and assembled? Once the project architect makes this decision, the drafters are selected and the drawing tasks are delegated.

Developing Construction Documents from a 3…D Model

A 3…D model, if one is generated, is rotated into the appropriate positions to obtain the roof plan and the corresponding elevations (see Figure 16.11). The 3…D model is sliced horizontally and vertically. The horizontal slice is used to produce the floor plan. If the roof half is rotated in the plan view, a reflected ceiling plan is produced. The vertical cut produces a view of the structure called a **building section**. For examples of the floor plan and building section, see Figure 16.12. A summary of the results of this exercise is shown in Figure 16.13.

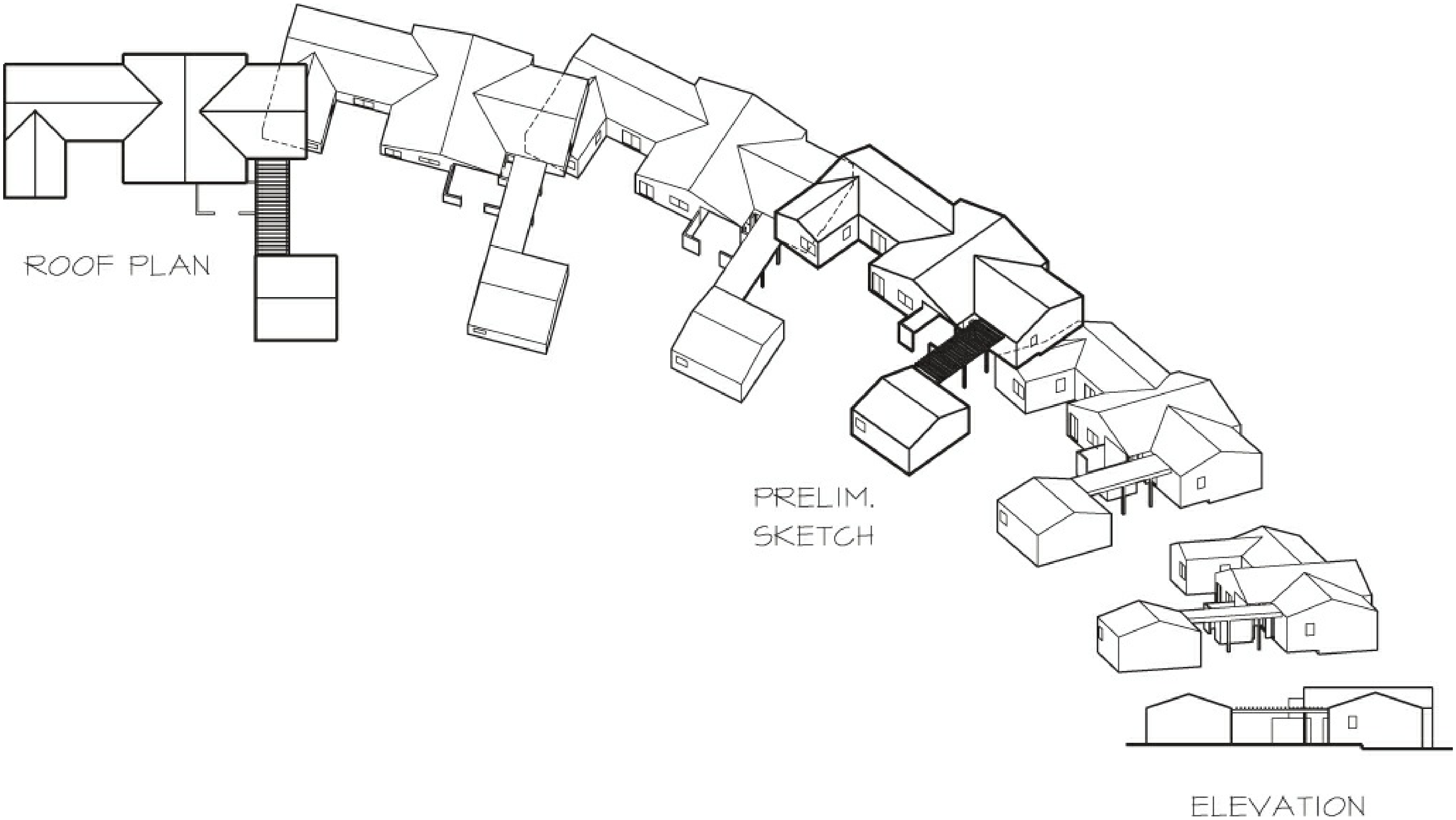
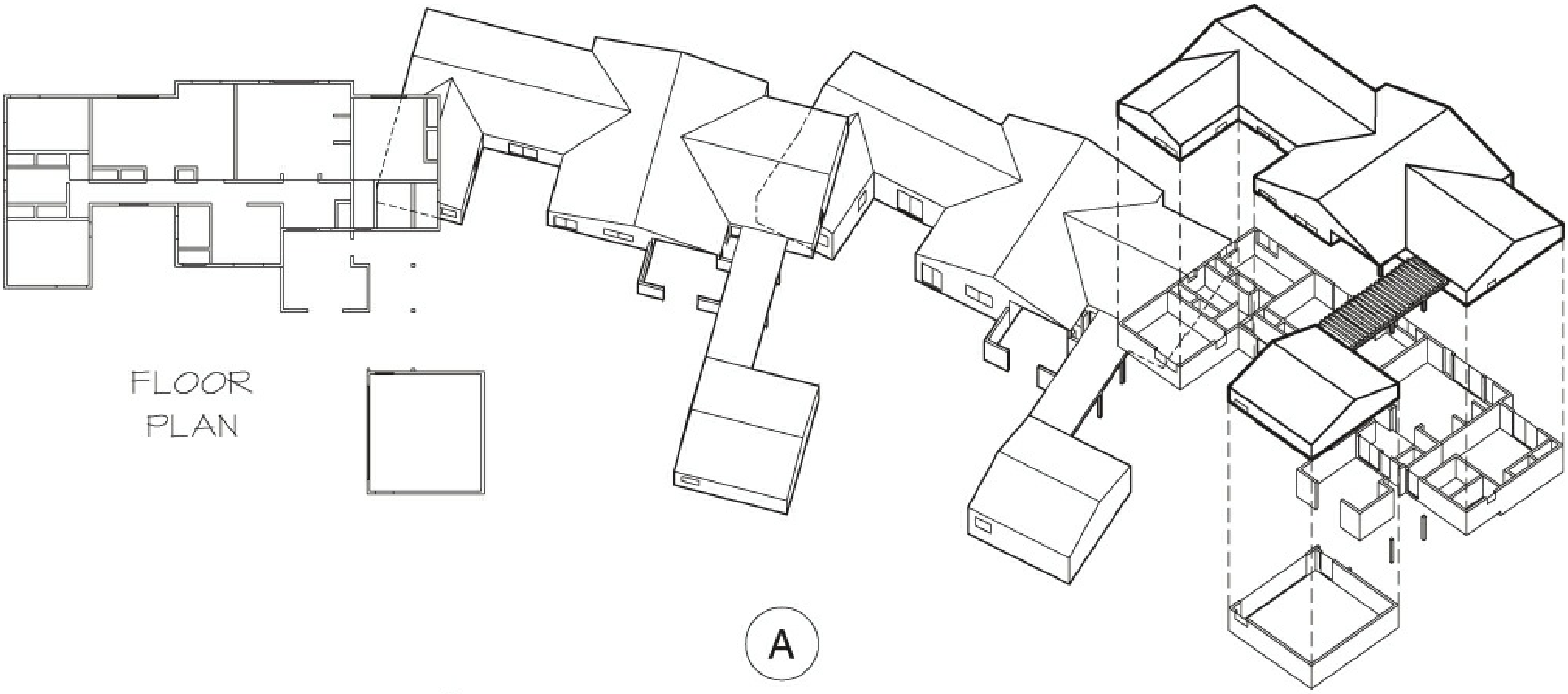
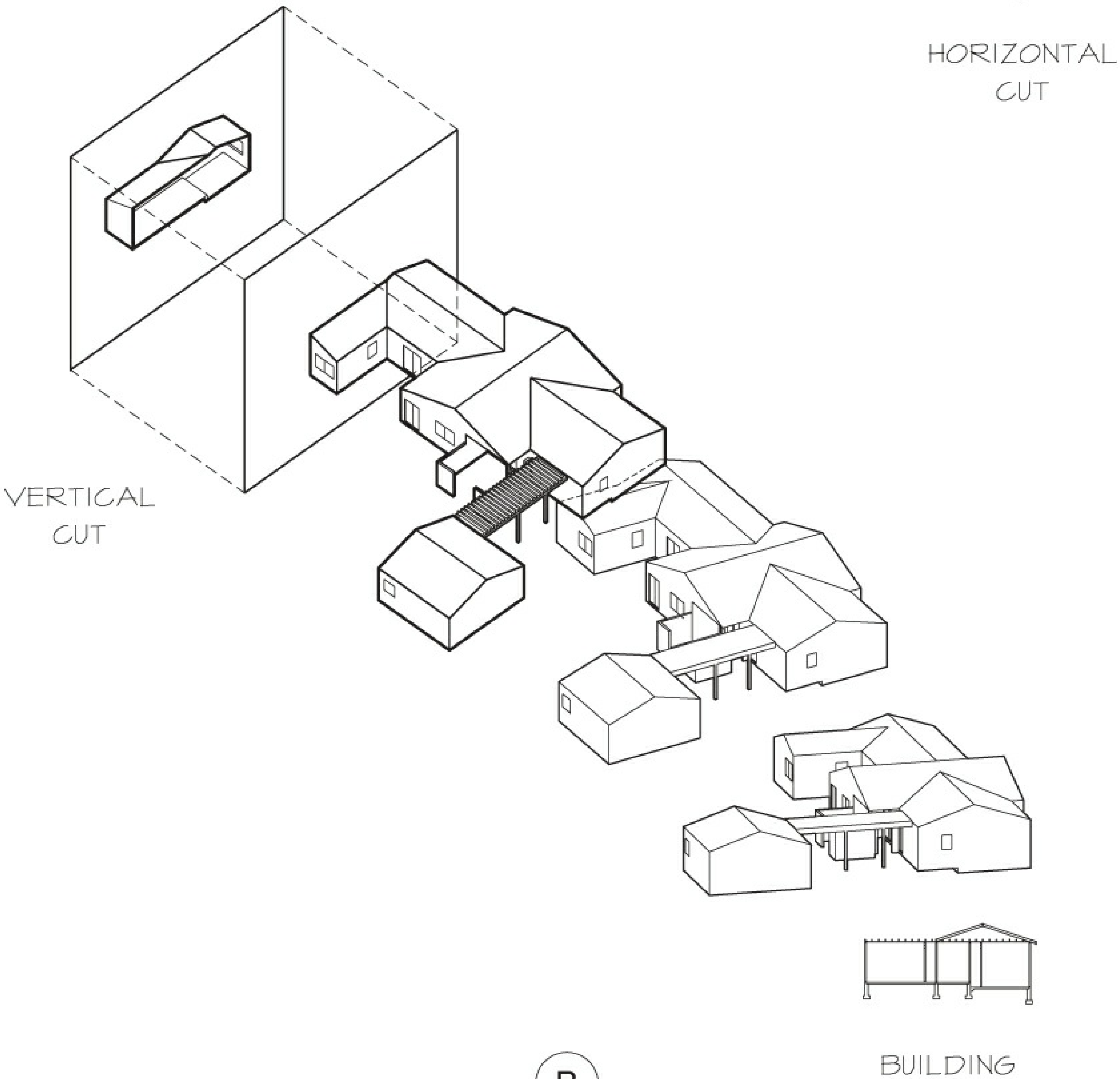


Figure 16.11 Rotation of massing model into ortho view.



A



B

Figure 16.12 Horizontal and vertical sections through preliminary sketch.

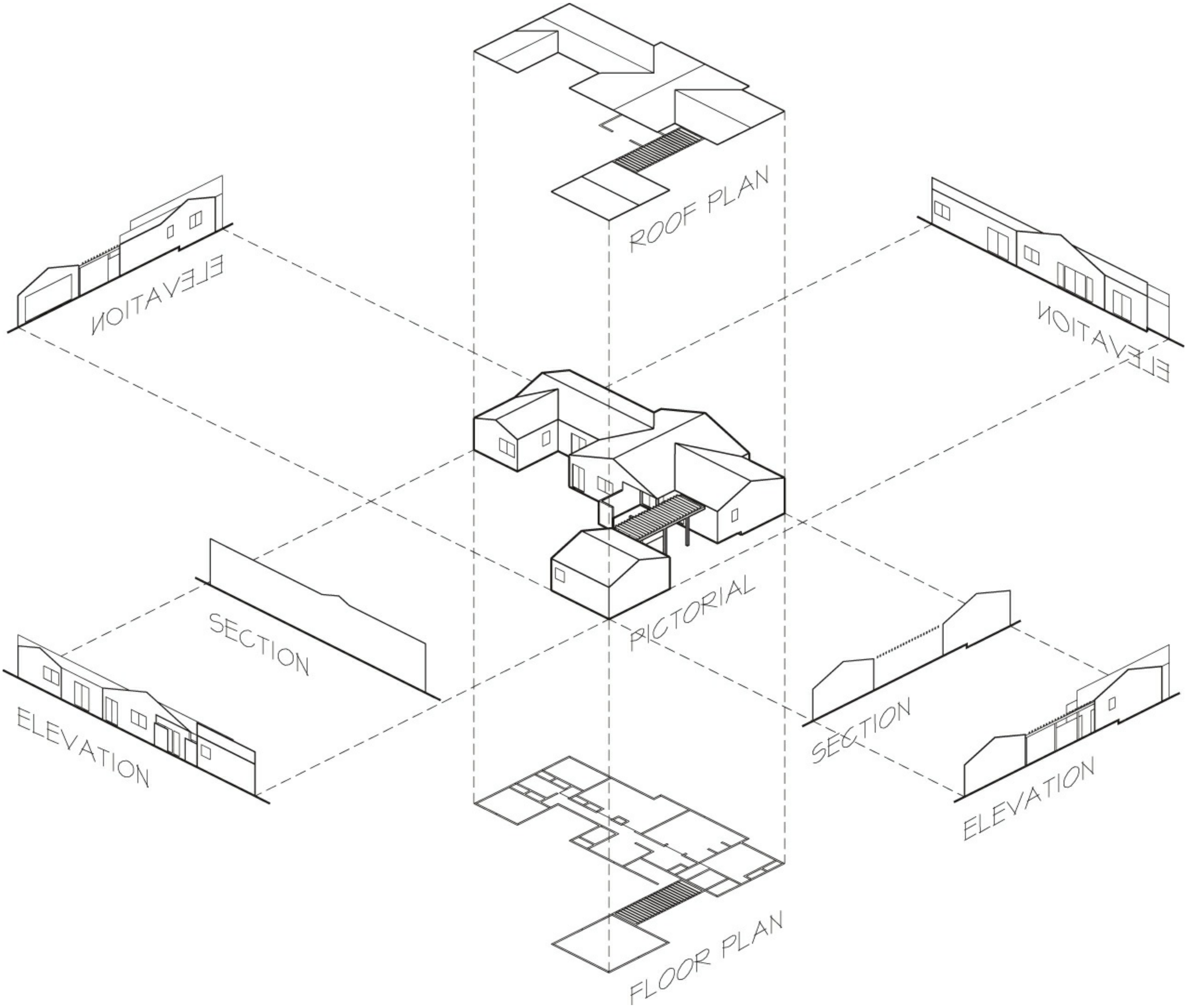


Figure 16.13 Evolution of construction documents.

The next step for the CAD drafter is to construct the structure as a 3…D model. See an example of such a section in Figure 16.14. Although this may seem like a lot of work at this stage, it really is not when you consider that the floor plan will be used as the base (datum) for the framing plan, electrical plans, mechanical plans, and foundation plans, as seen in Figure 16.15.

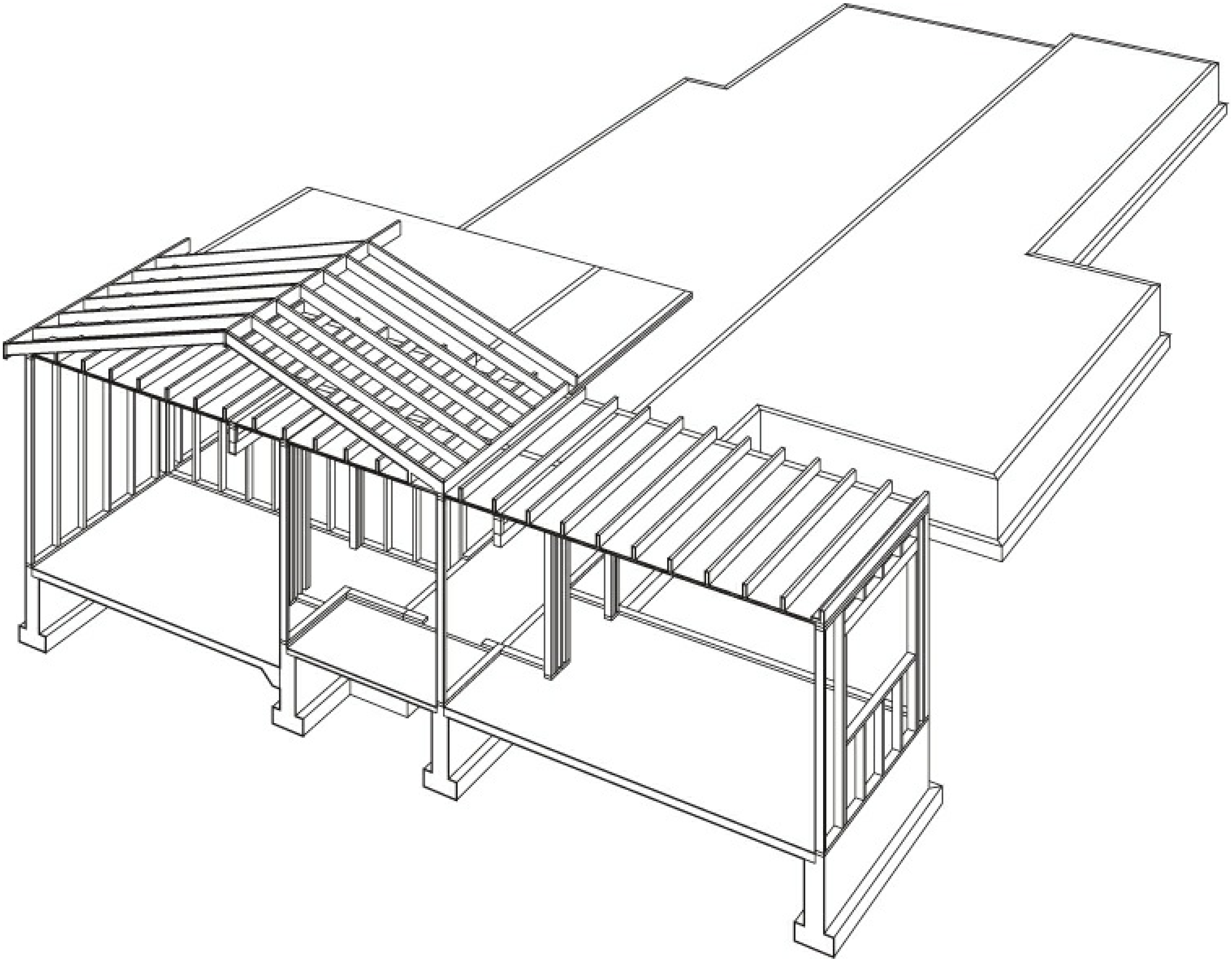


Figure 16.14 Incorporating the individual elements.

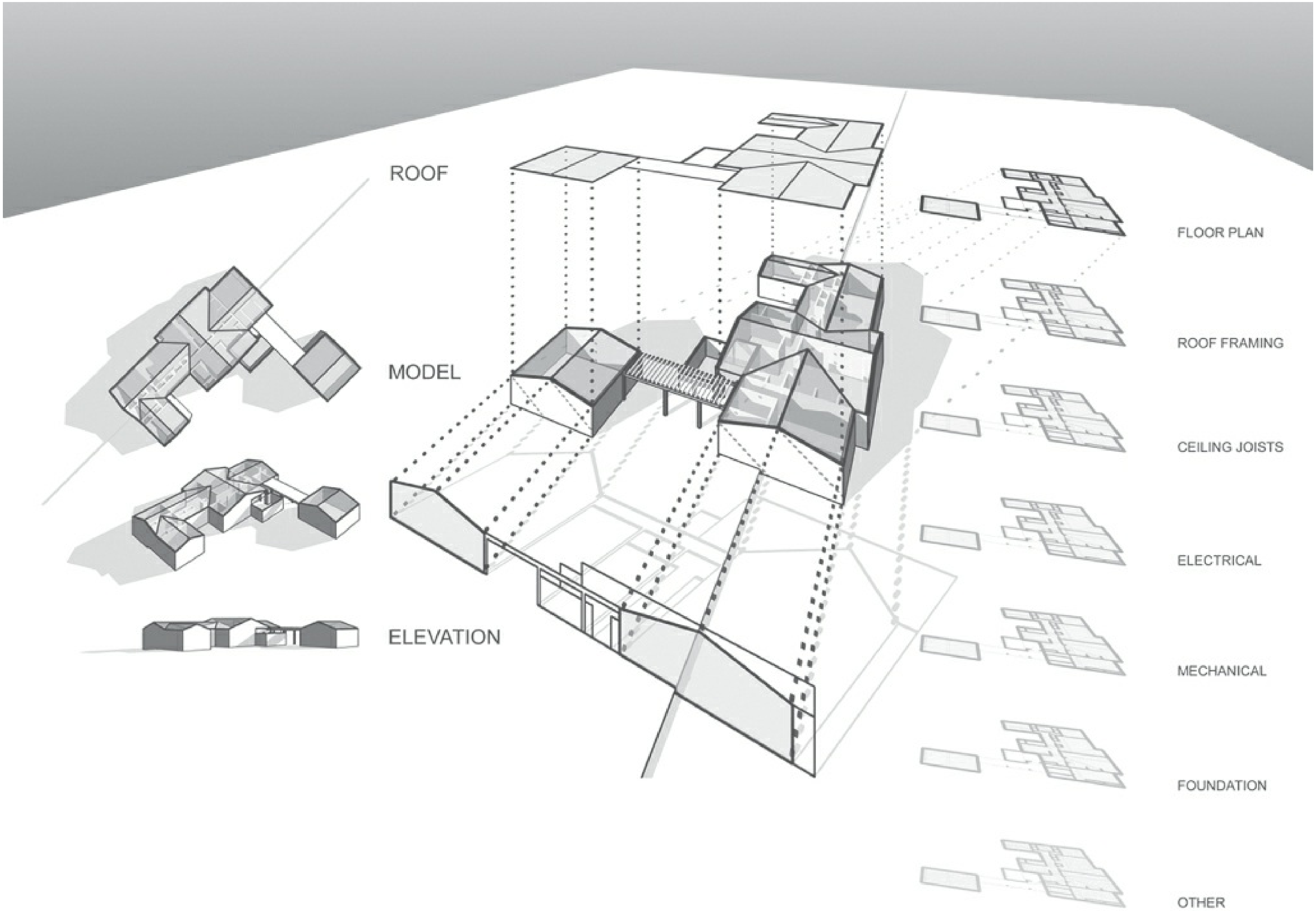


Figure 16.15 Floor plan as a base for other drawings.

The Jakob Residence

The design purpose is to create a home that has five rooms all on one level. The site is a typical city lot in Anytown, USA, and for this example we call it the Jakob residence. The zoning is R…3 (residential), the setbacks are 15′…0″ in the front, 6′…0″ on the sides, and 15′…0″ at the rear. Water flows to the rear in the direction of the lot's slope. See Figures 16.16 through 16.26.

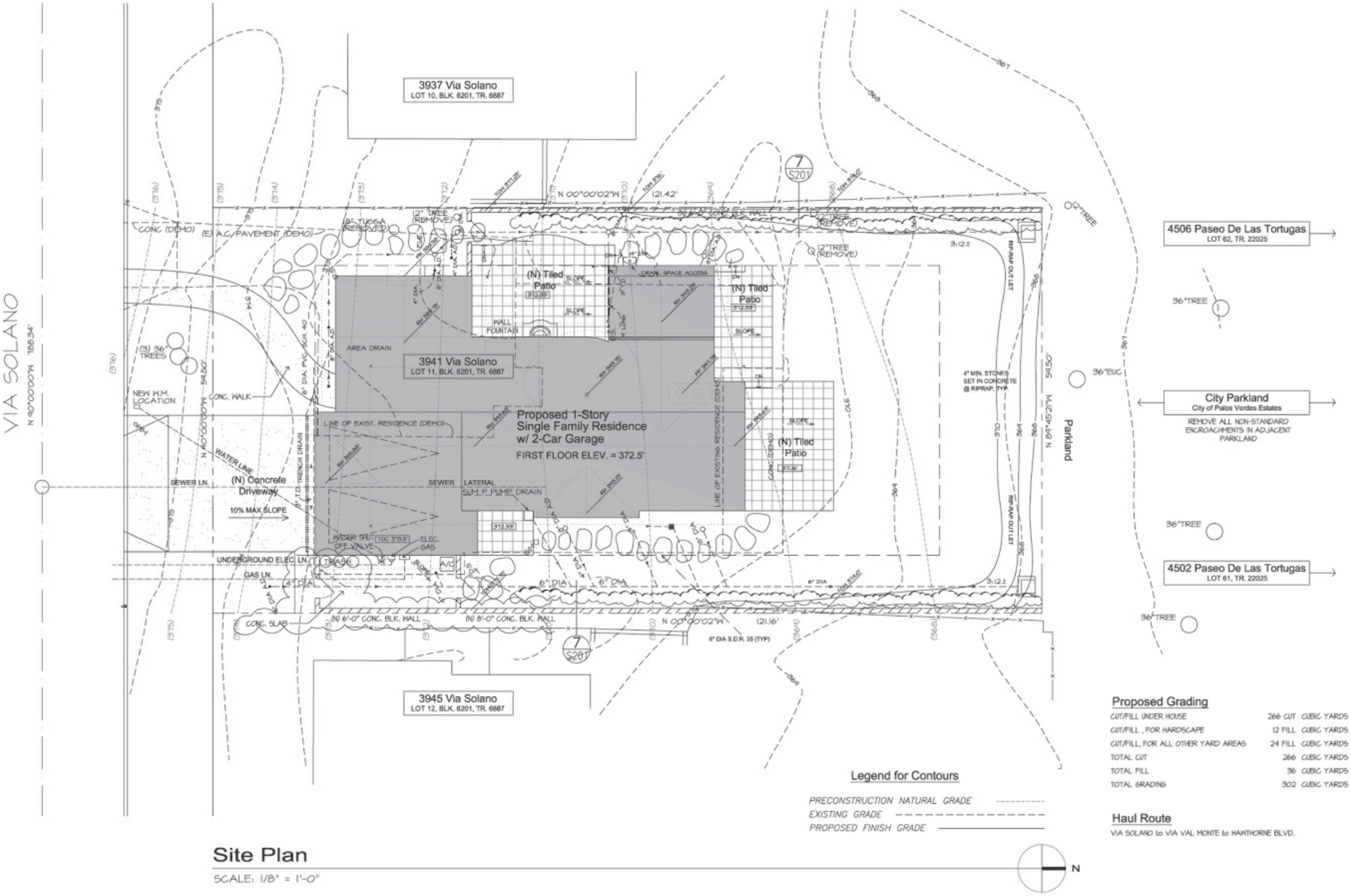


Figure 16.16 Jakob residence site plan.

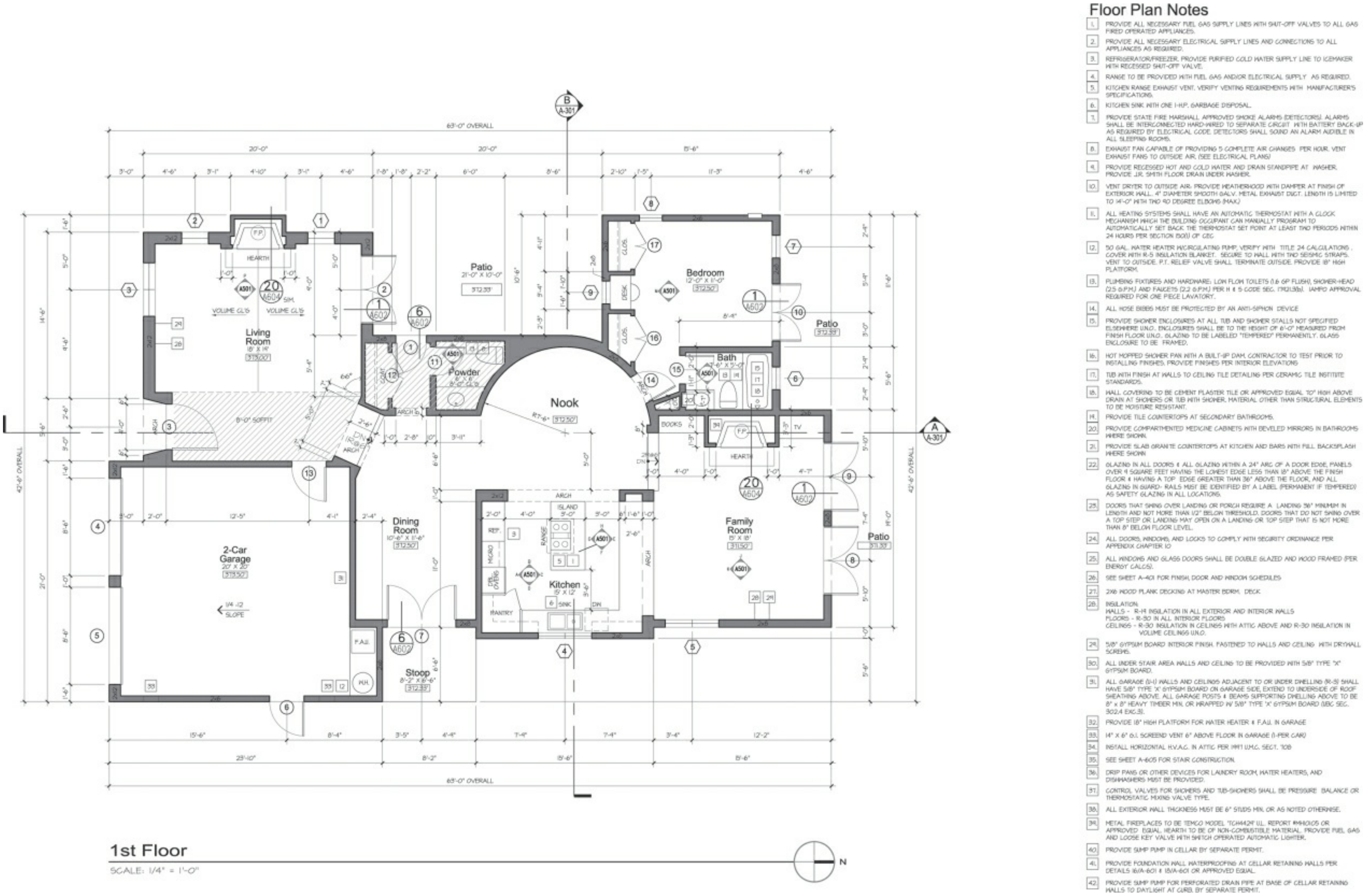


Figure 16.17 Floor plan.

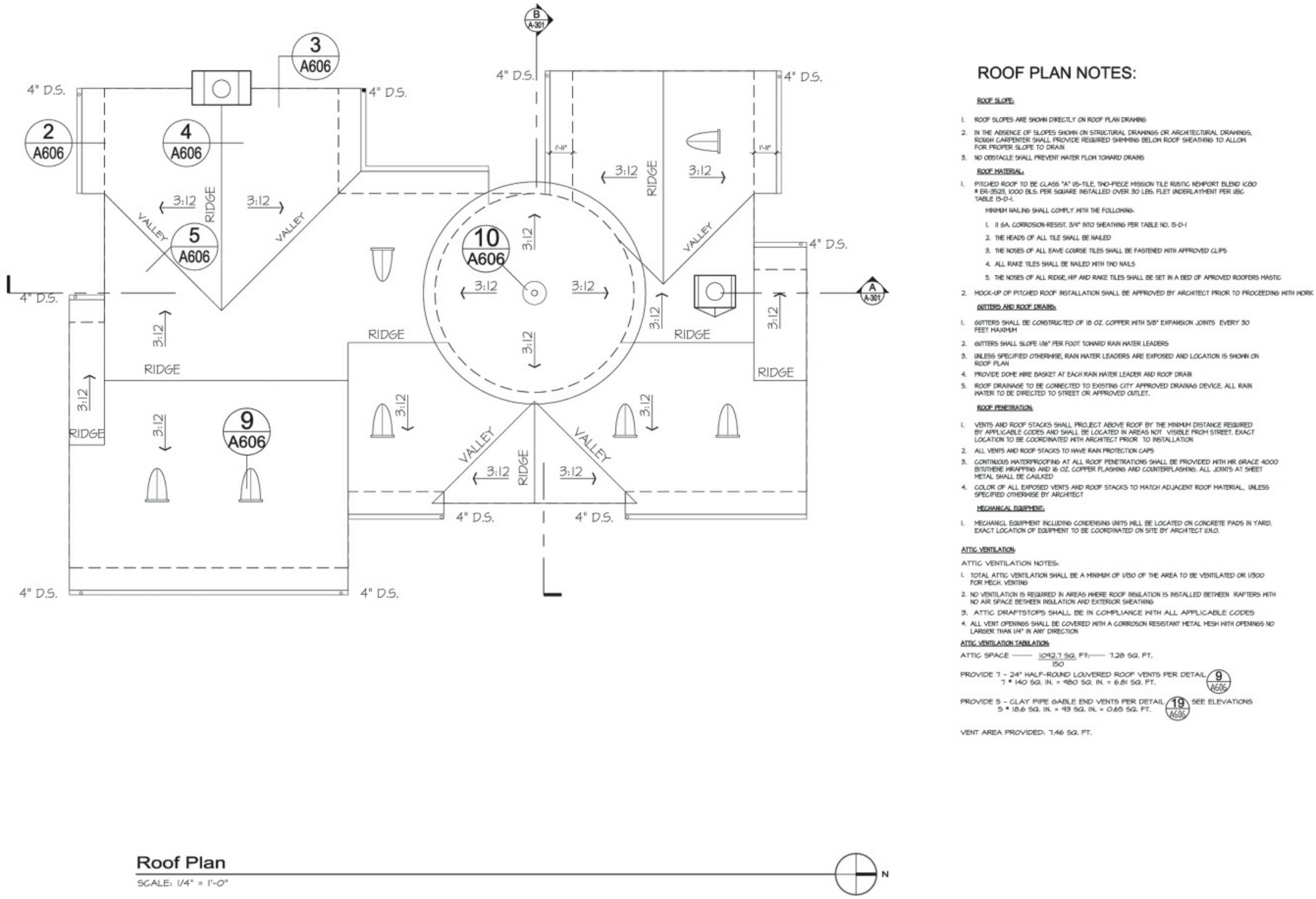
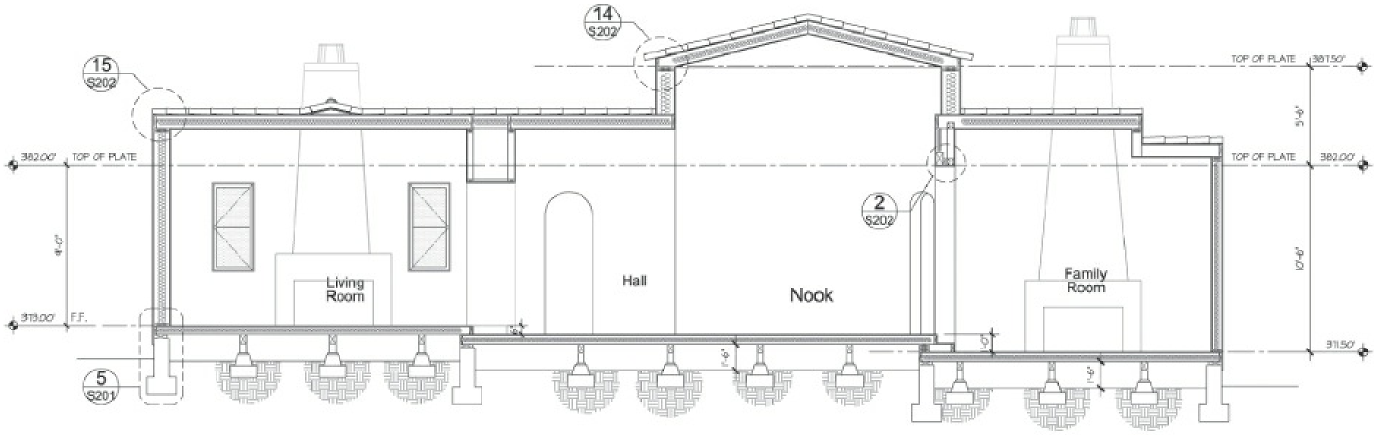
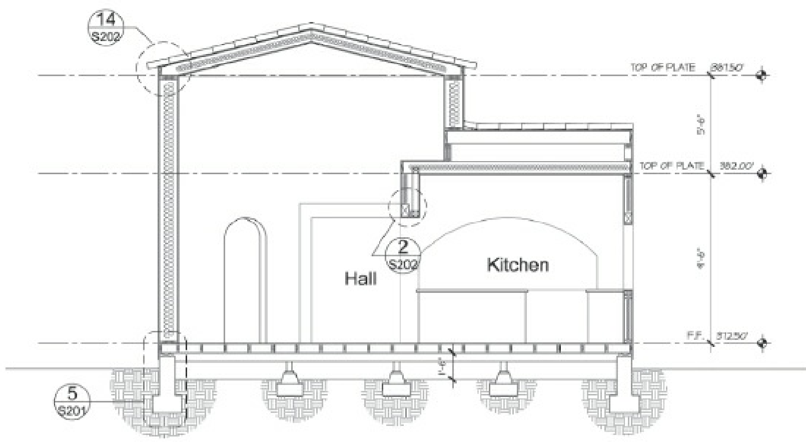


Figure 16.18 Roof plan.



Section A

SCALE: 1/4" = 1'-0"



Section B

SCALE: 1/4" = 1'-0"

SECTION NOTES:

1 CONCRETE STEM FOOTINGS PER STRUCTURAL ENGINEERS DRAWINGS AND SPECIFICATIONS

2 LOWER AND UPPER LEVEL WALLS TO BE 2X6 STUDS (UNLESS NOTED OTHERWISE) WITH SPACING AND SPECIFICATIONS PER STRUCTURAL ENGINEER. FIREBLOCK STUDS AT CEILING AND AT MID-HEIGHT OF STUDS BETWEEN FINISH FLOOR AND CEILING HEIGHT PER STRUCTURAL ENGINEER

3 SEE STRUCTURAL DRAWINGS FOR SIZE, SPACING AND SPECIFICATIONS OF ROOF RAFTERS

4 SEE STRUCTURAL DRAWINGS FOR SIZE, SPACING AND SPECIFICATIONS OF CEILING JOISTS

5 SEE STRUCTURAL DRAWINGS FOR SIZE, SPACING AND SPECIFICATIONS OF FLOOR JOISTS

6 FLOOR SHEATHING: TONGUE AND GROOVE PLYWOOD. PROVIDE A CONTINUOUS BEAD OF CONSTRUCTION ADHESIVE BETWEEN PLYWOOD AND SUPPORTS. ALL FLOOR SHEATHING TO BE SCREWED. SEE STRUCTURAL DRAWINGS FOR SIZE, SPACING AND SPECIFICATIONS

7 ROOF SHEATHING: SEE STRUCTURAL DRAWINGS FOR SIZE, SPACING AND SPECIFICATIONS. VERIFY WITH ROOF MANUFACTURERS SPECIFICATIONS AND RECOMMENDATIONS (ROOF SHEATHING CONTINUES UNDER CALIFORNIA FRAMING)

8 INSULATION:
EXTERIOR WALLS - R-19
INTERIOR WALLS - R-13
ROOF - R-30 2X6 R.R. / R-19 2X8 R.R.
CEILING JOISTS - R-30
FLOOR JOISTS - R-30
GARAGE - R-19

9 5/8" GYPSUM BOARD INTERIOR FINISH, FASTENED TO WALLS AND CEILING WITH DRYWALL SCREWS.

10 ALL UNDER STAIR AREA WALLS AND CEILING TO BE PROVIDED WITH 5/8" TYPE "X" GYPSUM BOARD.

11 ALL GARAGE (U-1) WALLS AND CEILINGS ADJACENT TO OR UNDER DWELLING (R-3) SHALL HAVE 5/8" TYPE 'X' GYPSUM BOARD ON GARAGE SIDE, EXTEND TO UNDERSIDE OF ROOF SHEATHING ABOVE. ALL GARAGE POSTS & BEAMS SUPPORTING DWELLING ABOVE TO BE 8" x 8" HEAVY TIMBER MIN. OR WRAPPED W/ 5/8" TYPE 'X' GYPSUM BOARD (UBC SEC. 302.4 EXC.3).

12 SEE ROOF PLAN (SHT. #A-301) FOR ROOFING, NOTES AND DETAILS

13 SEE DETAILS 1/A-605 - 13/A-605 FOR STAIR CONSTRUCTION

14 EXTERIOR PLASTER ON ALL EXTERIOR WALLS AND SOFFITS: 7/8" SMOOTH STEEL TROWEL INTREGAL COLOR WITH STUCCO-RITE SFB SELF-FURRING LATH WITH GRADE "D" BREATHER BUILDING PAPER BACKING. ALL OUTSIDE CORNERS BEADED. (2-LAYERS OF FELT PAPER REQUIRED WHEN INSTALLED OVER PLYWOOD)

15 4X8 OUTLOOKERS @ 24" O.C. AT ALL OVERHANGS

16 14"X6" G.I. SCREENED VENT 6" ABOVE FLOOR IN GARAGE (1-PER CAR)

17 PROVIDE 24"X18" (MIN.) UNDER-FLOOR ACCESS. (SECT. 2306.3 U.B.C.) PROVIDE 6-MIL VISQUINE PROTECTED BY 2 1/2" SAND FOR DAMP PROOFING CRAWLSPACE. (SEE PLANS FOR LOCATION)

18 PROVIDE 14"X6" VENTS FOR UNDER-FLOOR VENTILATION. (SECT.2306.7 U.B.C.)

Figure 16.19 Elevations.

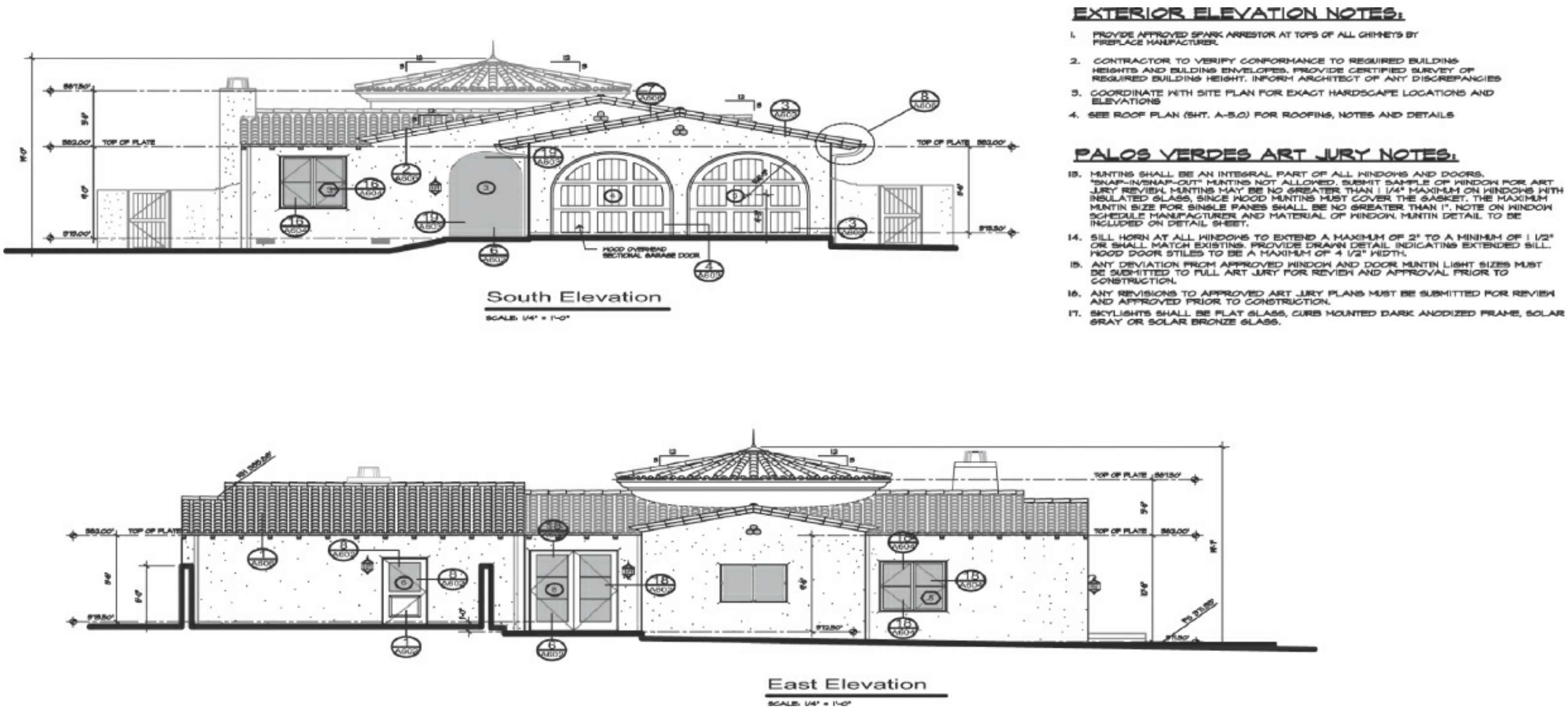


Figure 16.20 Sections.

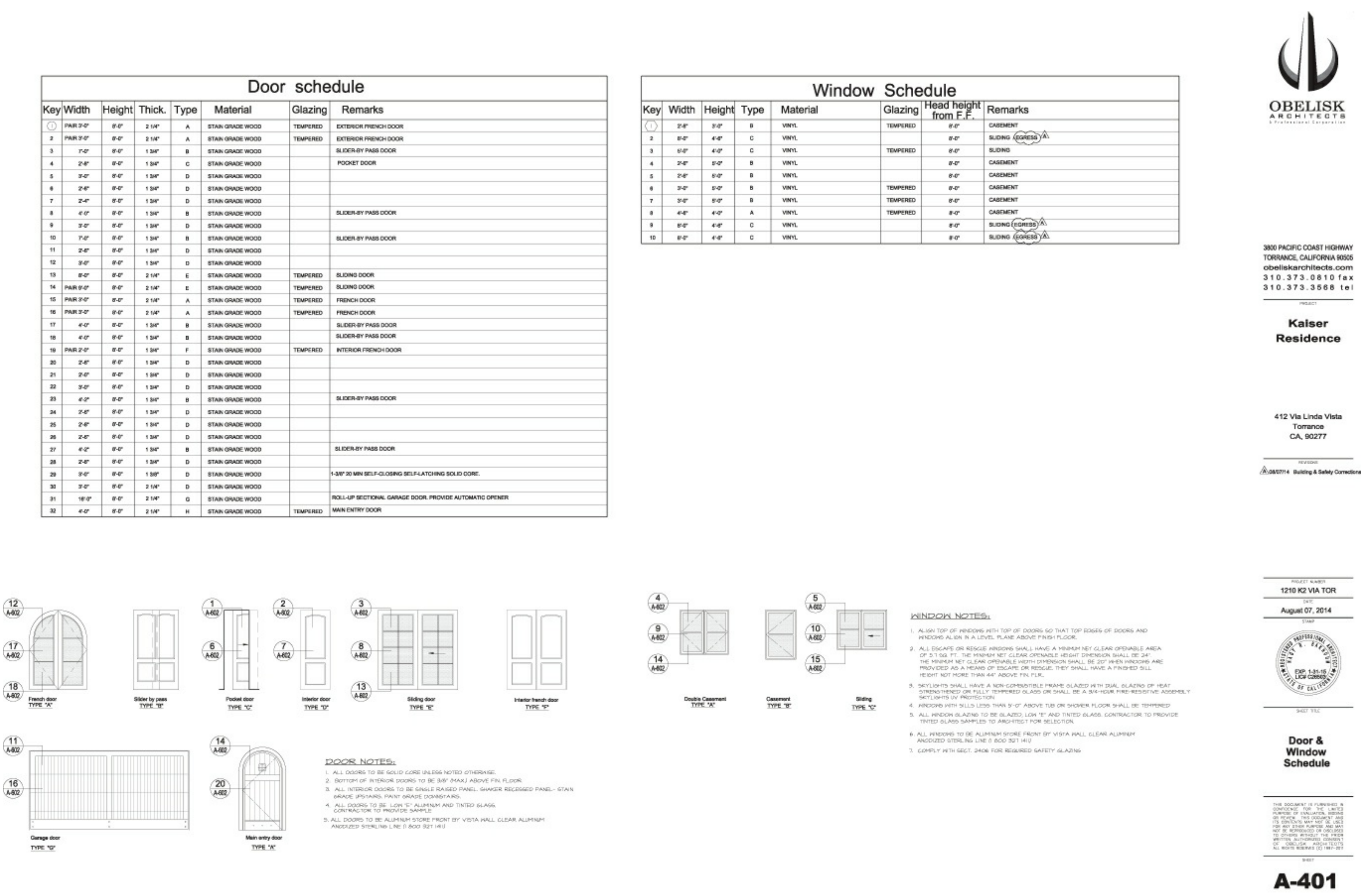
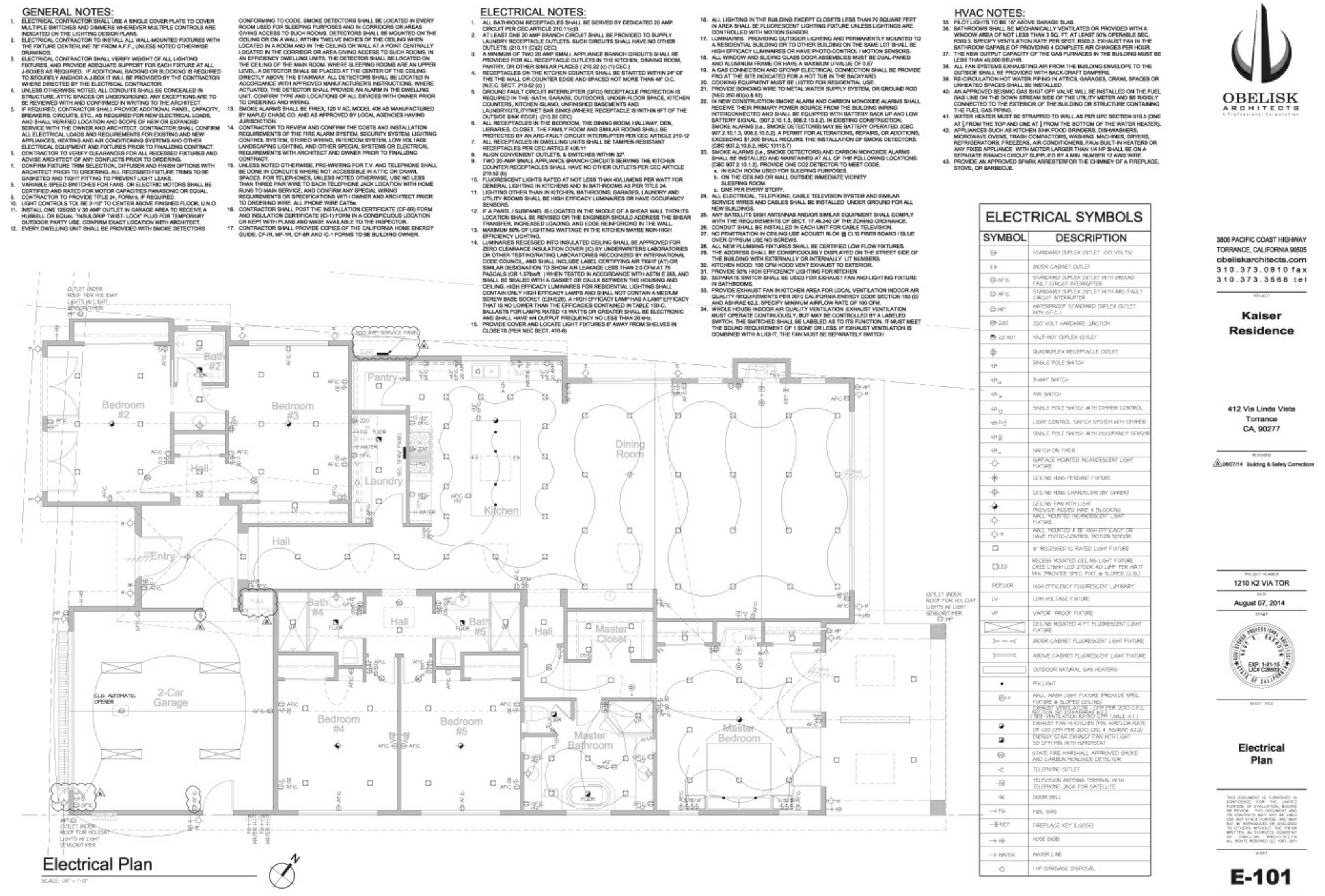


Figure 16.21 Schedules.



[**Figure 16.22**]() Electrical plan.

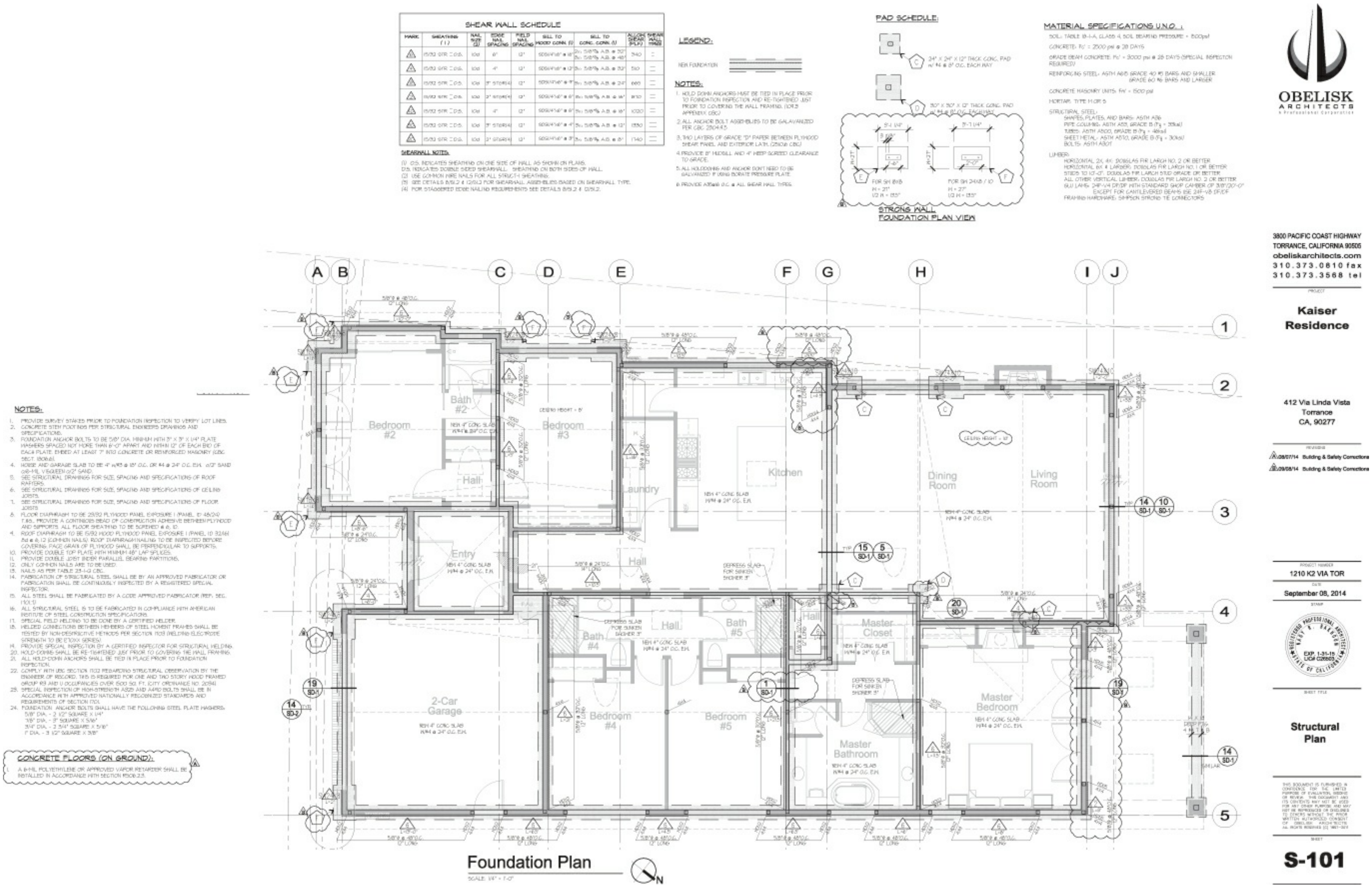
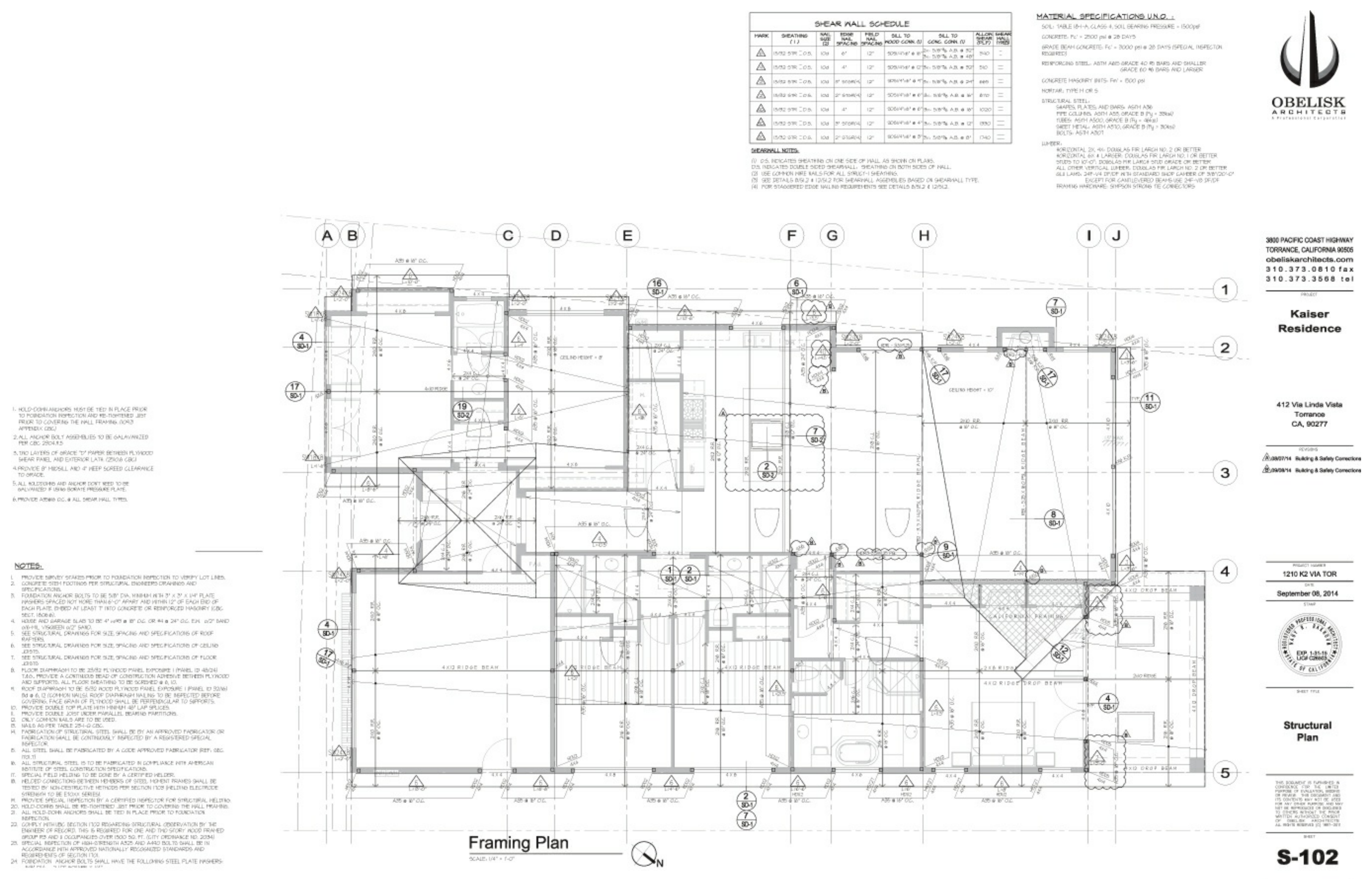


Figure 16.23 Foundation plan.



[**Figure 16.24**](#) Framing plan.

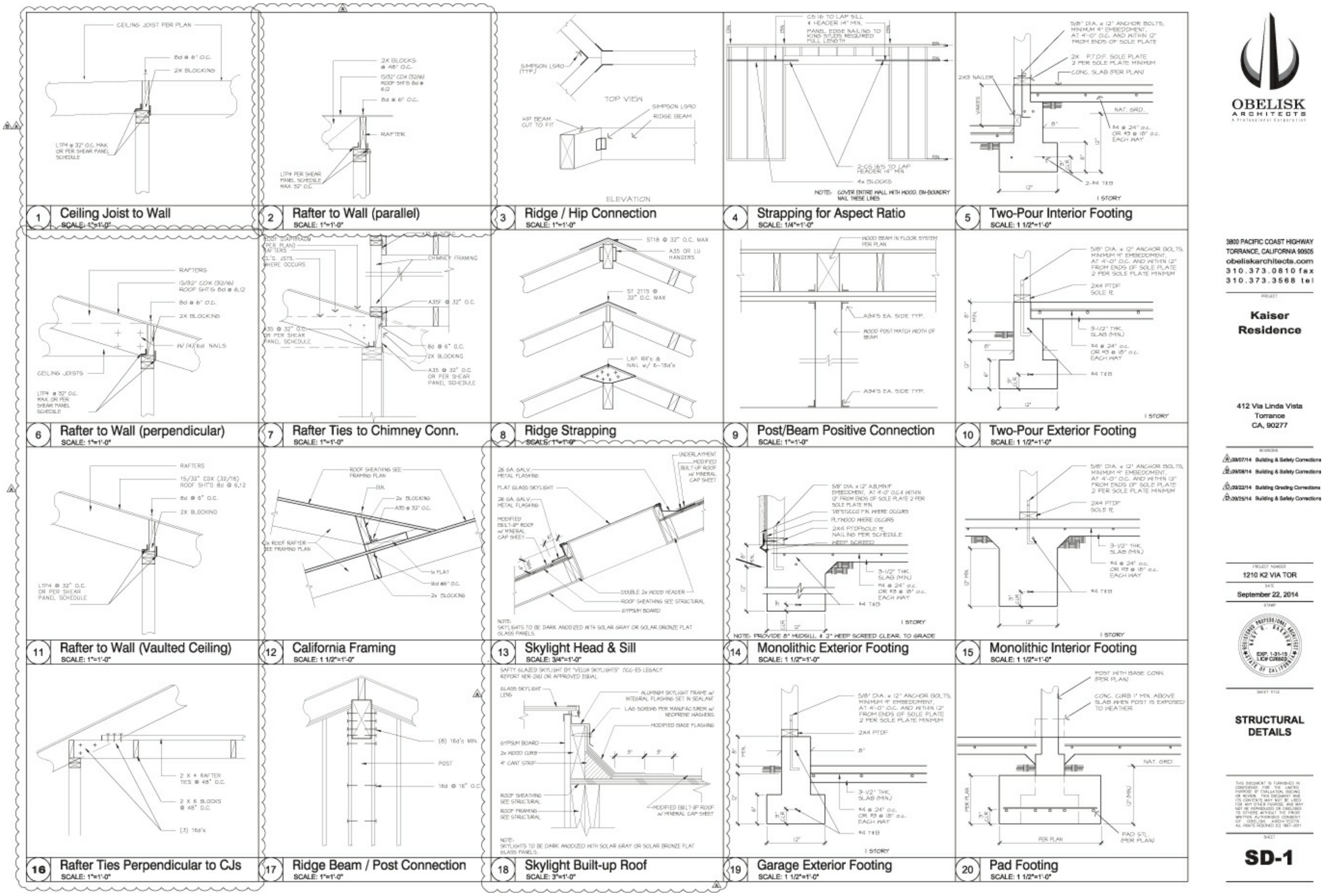


Figure 16.25 Structural details.

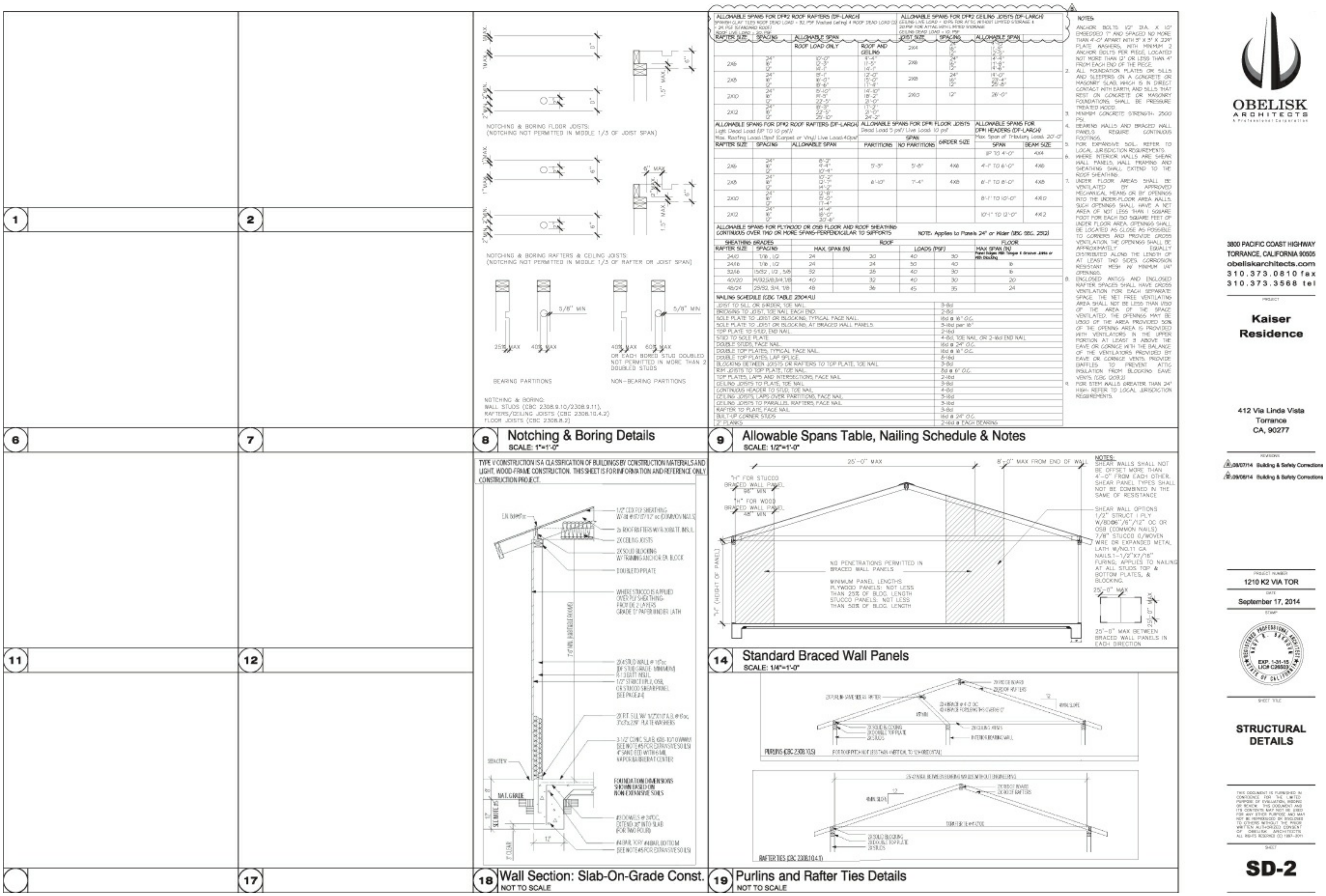


Figure 16.26 Structural details.

Key Terms

- bubble diagramming
- building section
- cartoon sheet
- mock set

Chapter 17
CONSTRUCTION DOCUMENTS FOR A TWO‥STORY, WOOD‥FRAMED RESIDENCE WITH BIM

INTRODUCTION

The clients, a young husband and wife with children, wanted to develop the site to its maximum potential. The site allowed a two‥story residence with a maximum floor area of 2900 square feet measured from the outside wall dimensions. Given these two factors, they wanted the following rooms: living room, dining room, kitchen, nook, study or

family room, guest bath, mud room and laundry, and three bedrooms with two full bathrooms and a gym. They also wanted a two…car garage. These requirements are termed the **program**.

Initial Schematic Studies

Our initial schematic studies worked through the relationships among the rooms as well as room orientation on the site. Room orientation required that we locate the major rooms, such as the family room, kitchen, and master bedroom, so that they would face the ocean and capture a city view. The garage and entry had to be adjacent to the road for accessibility.

Because the site is small, and because the setback regulations further reduced the buildable area, we obviously needed to design a two…story building to meet the clients' requested number of rooms.

First Floor. Figure 17.1 shows a schematic study of the first…floor level. This figure also illustrates some early decisions we made: locating the entry court on the south side of the building; providing access to the city view from the kitchen, nook, and family room; locating the dining room and living room in an area that would allow access from the outside; and providing a basement area for the mechanical system, the wine storage area, and the gym.

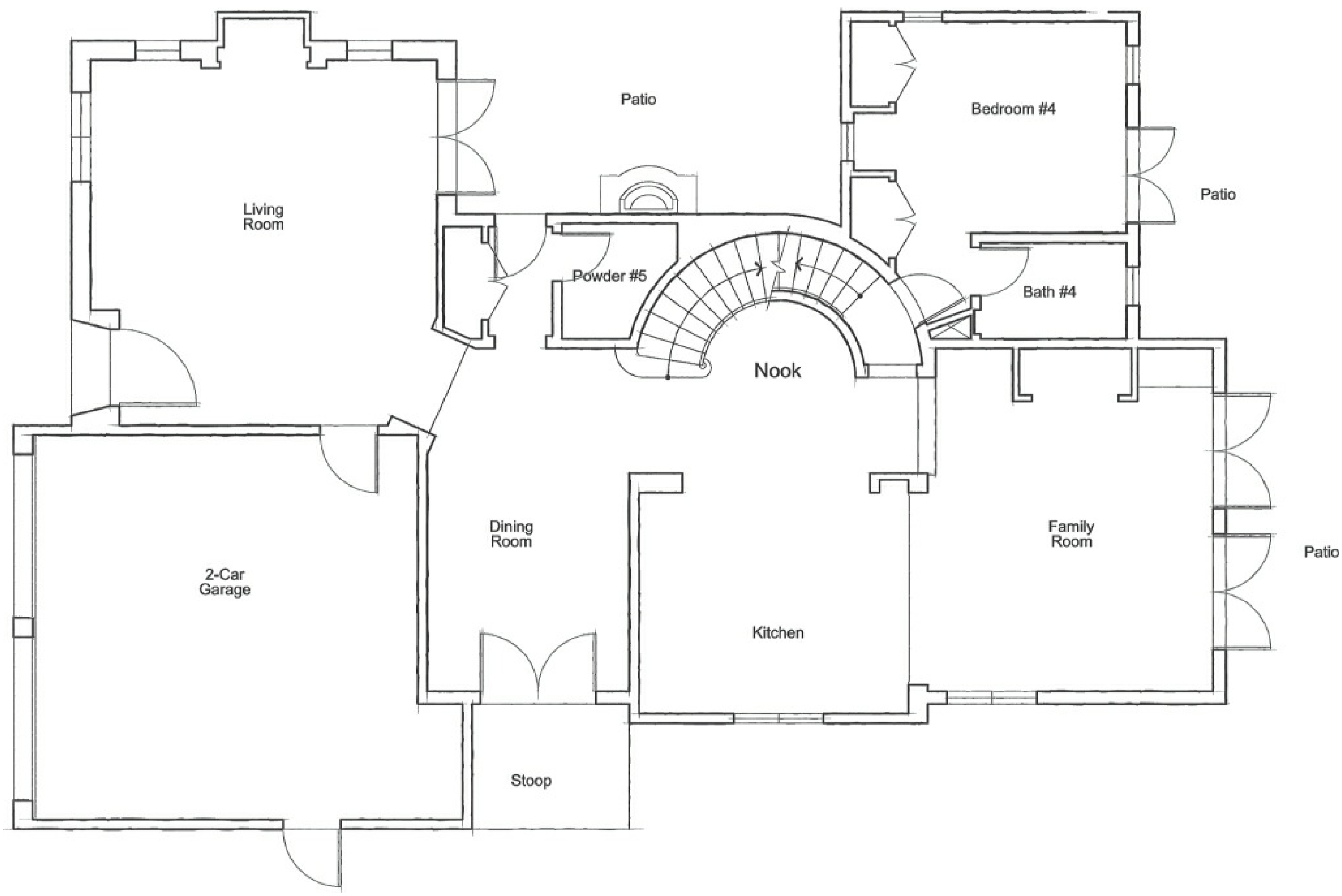


Figure 17.1 Schematic study—first floor of the Blu residence.

Second Floor. We developed a schematic study for the second…floor level to show the desired location and relationships among the rooms, as well as a possible deck location. We attempted to provide lots of natural light for all secondary bedrooms. See Figures 17.2 through 17.46 .

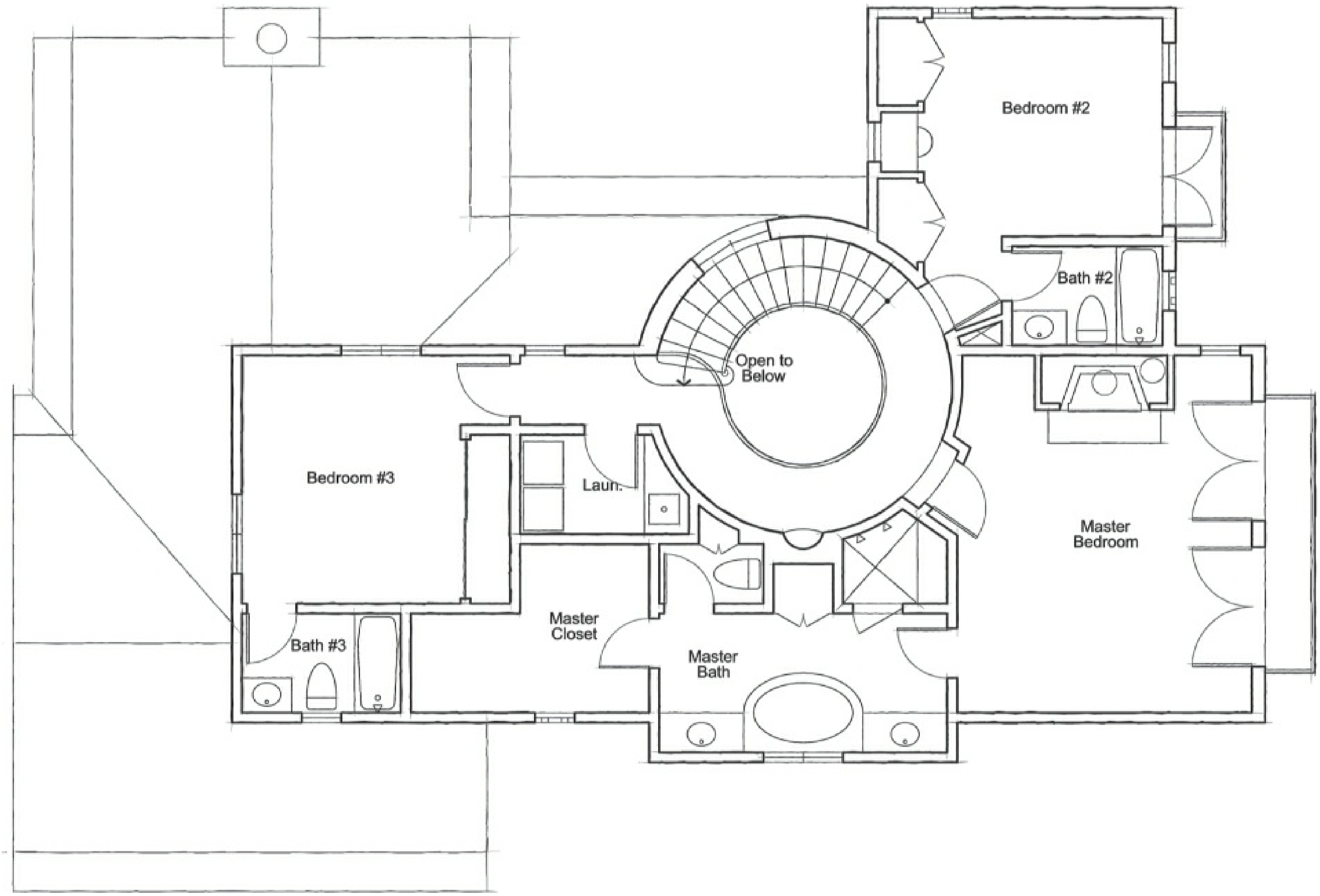


Figure 17.2 Schematic study—second floor of the Blu residence.

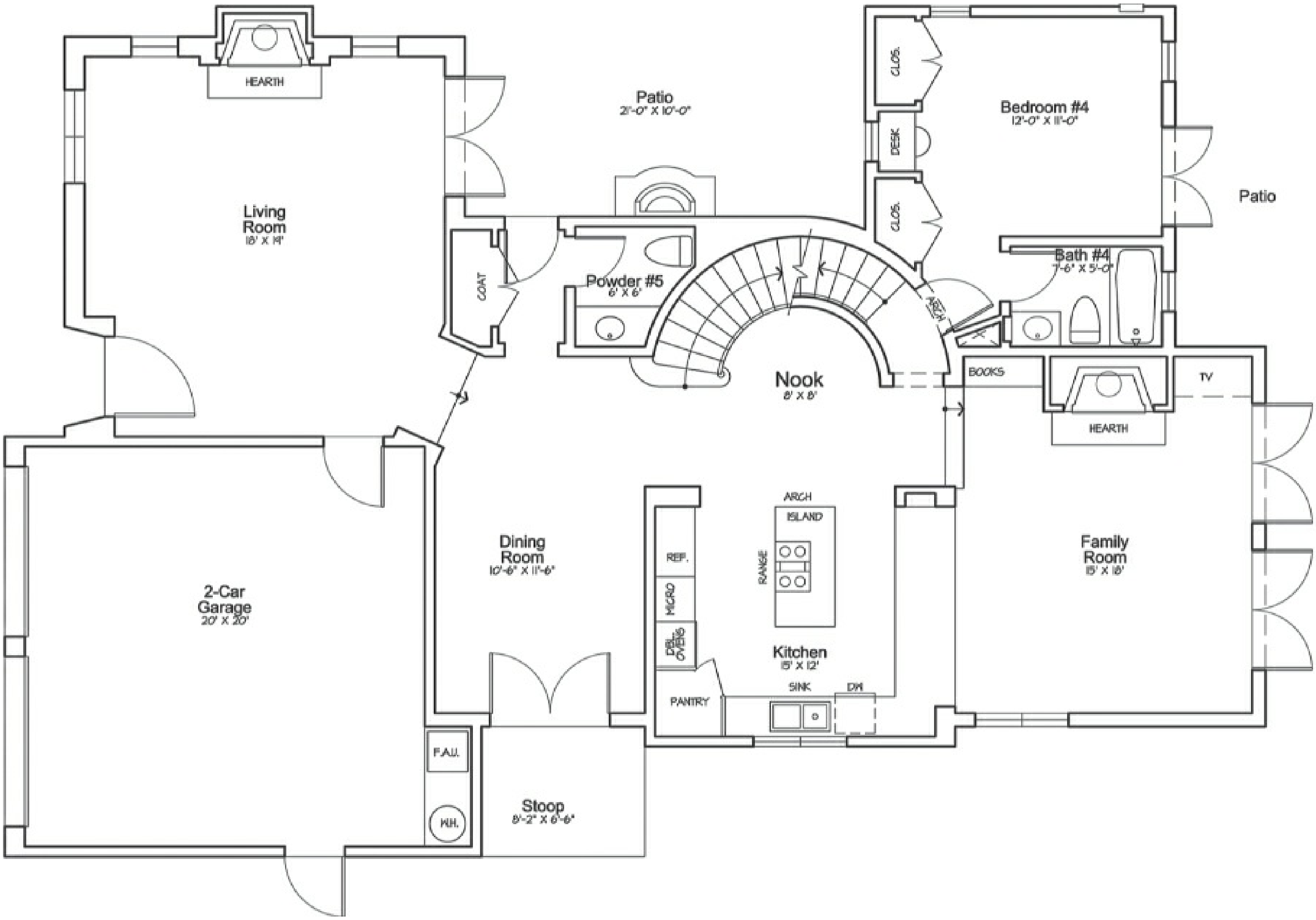


Figure 17.3 First…floor preliminary plan.

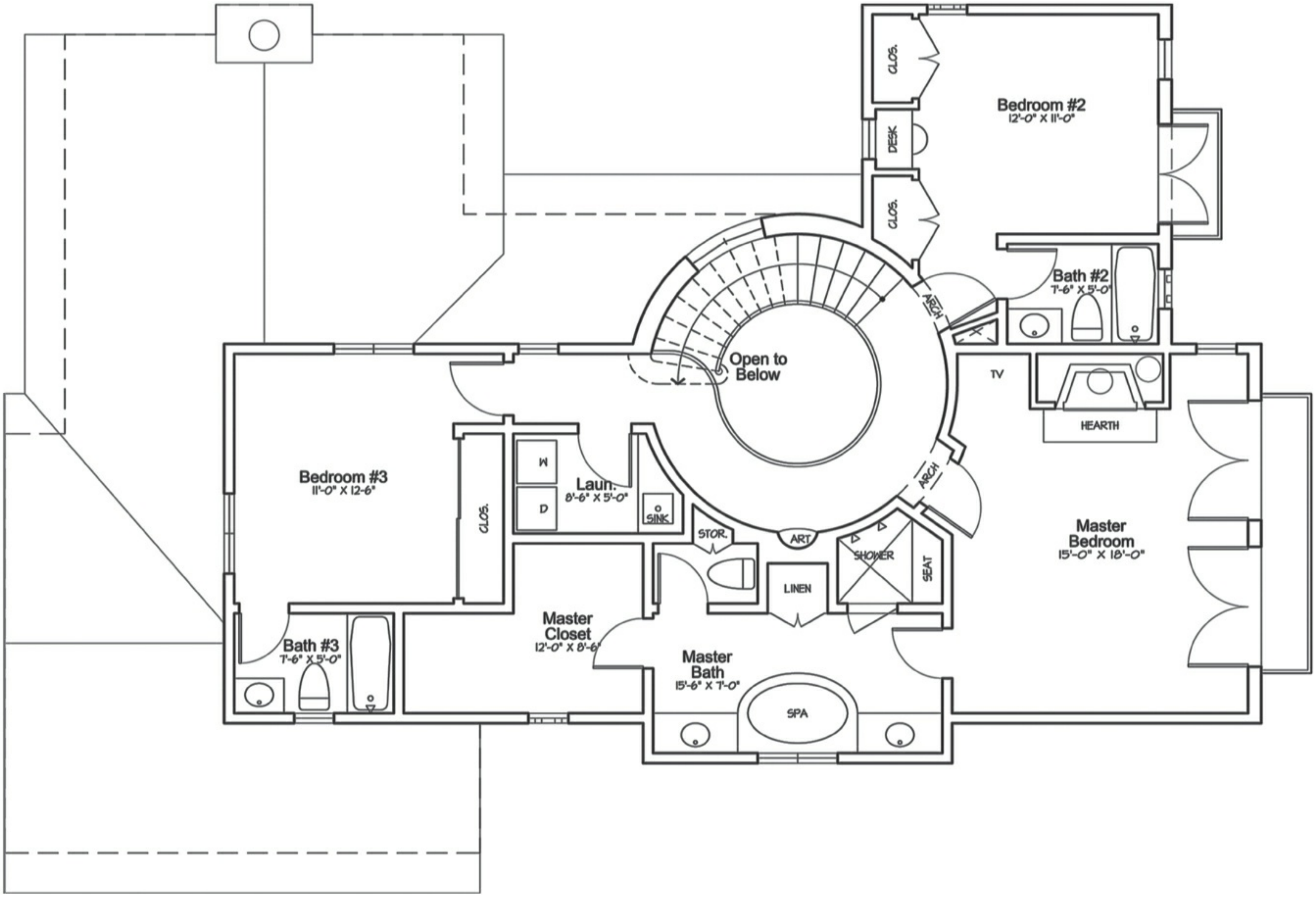


Figure 17.4 Second‐floor preliminary plan.

Figure 17.5 Conceptual designs of the exterior elevations.

Figure 17.6 Stage II: Site plan.

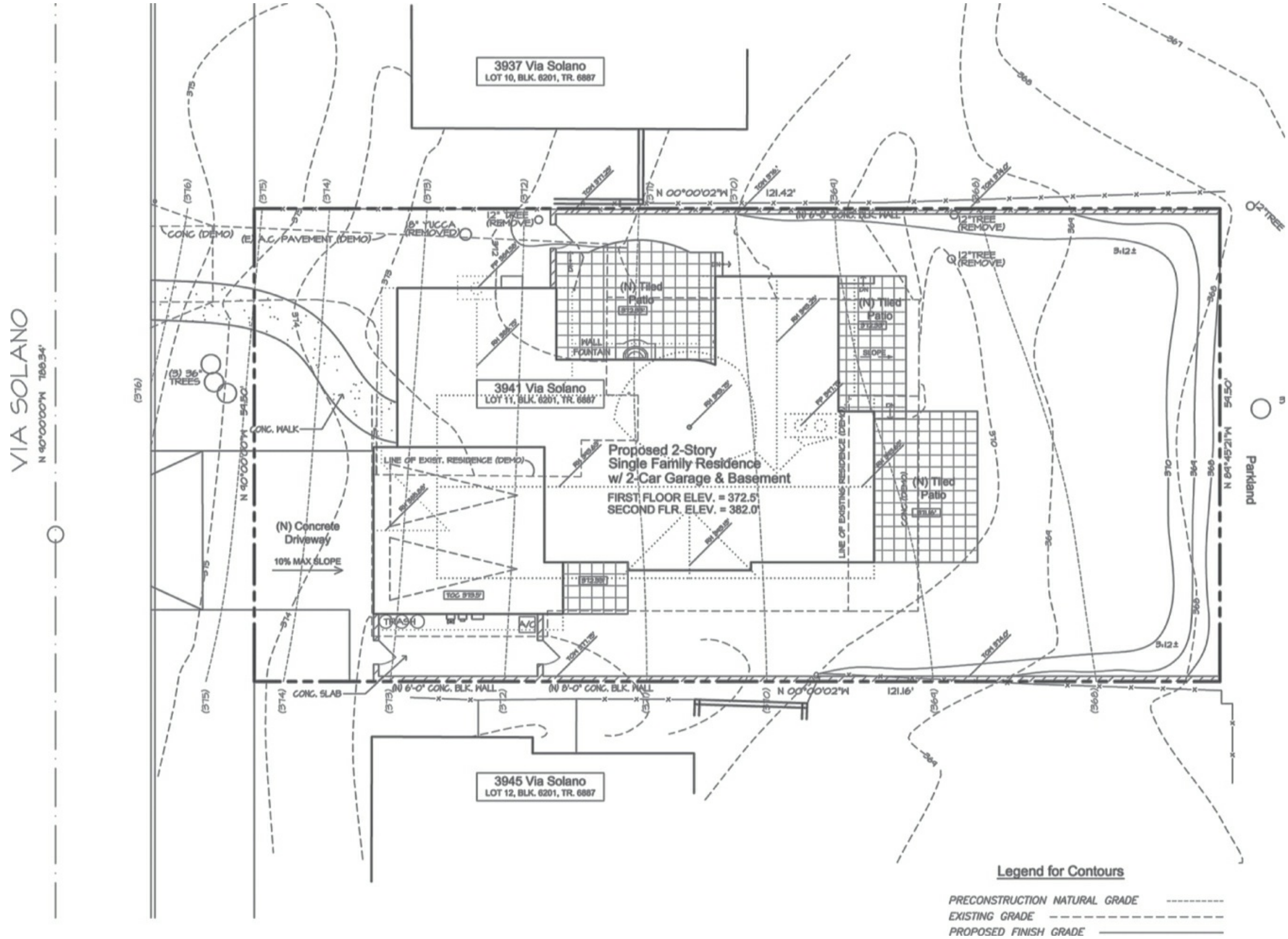


Figure 17.7 Stage III: Site plan.

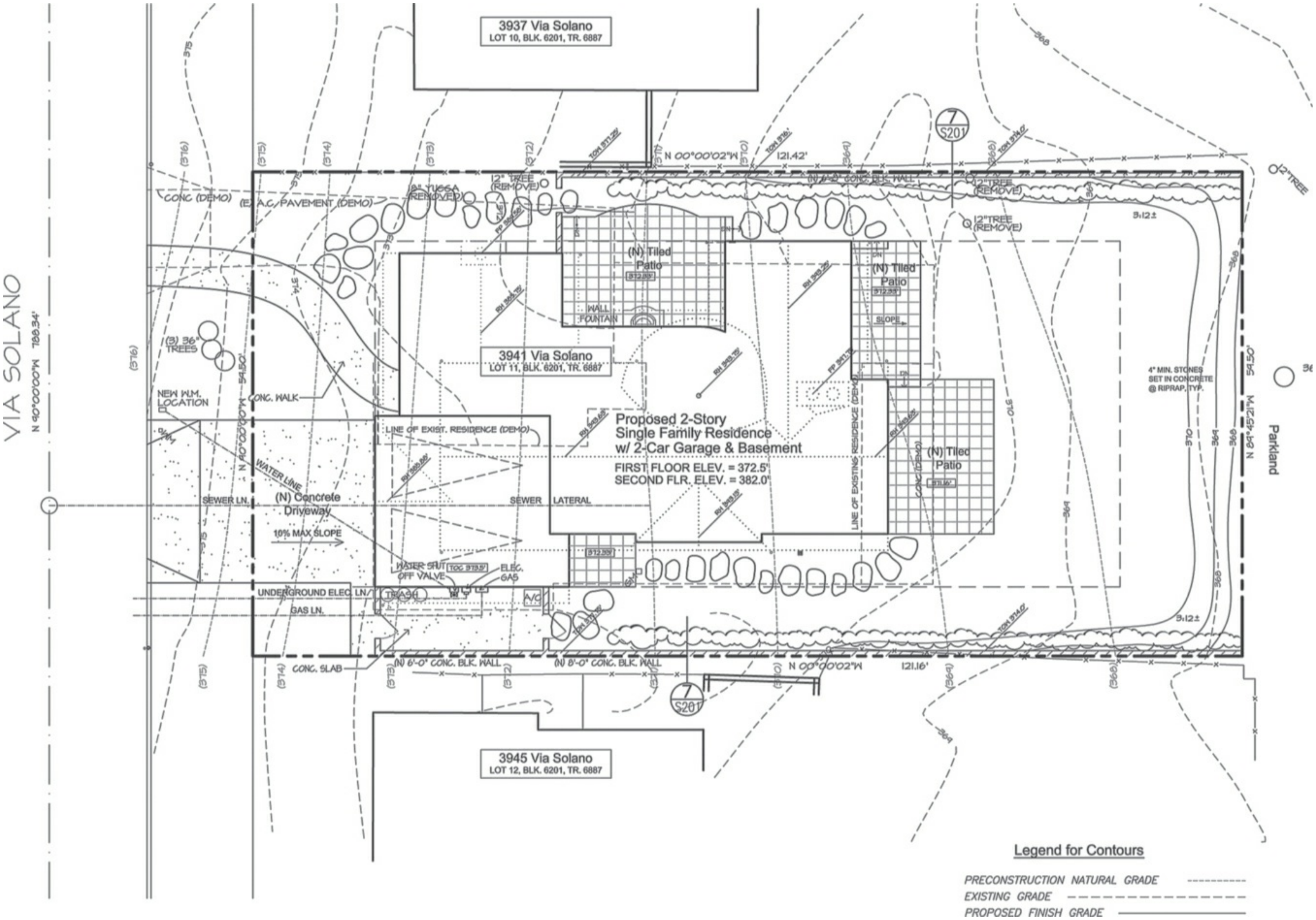


Figure 17.8 Stage IV: Site plan.

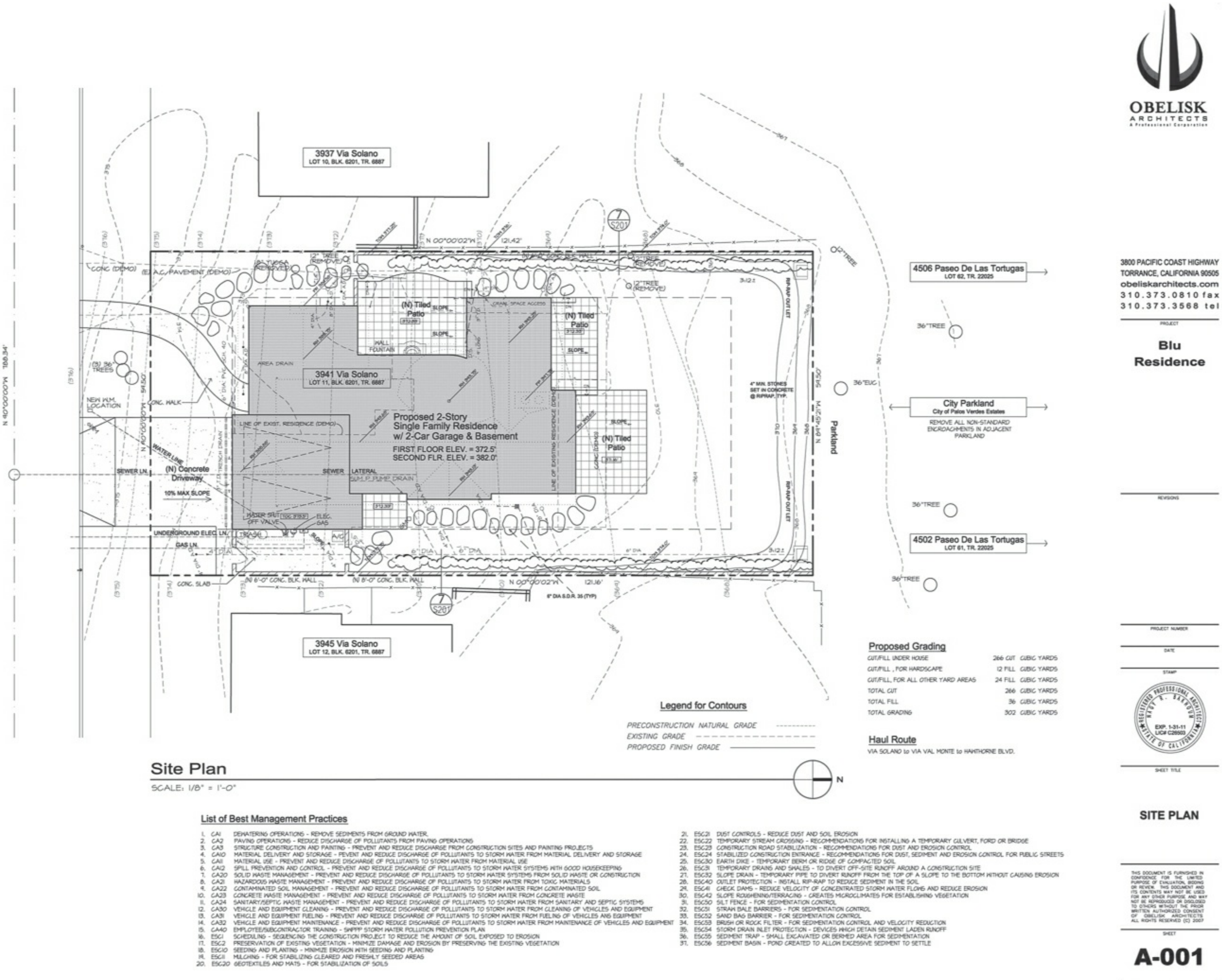


Figure 17.9 Stage V: Site plan.

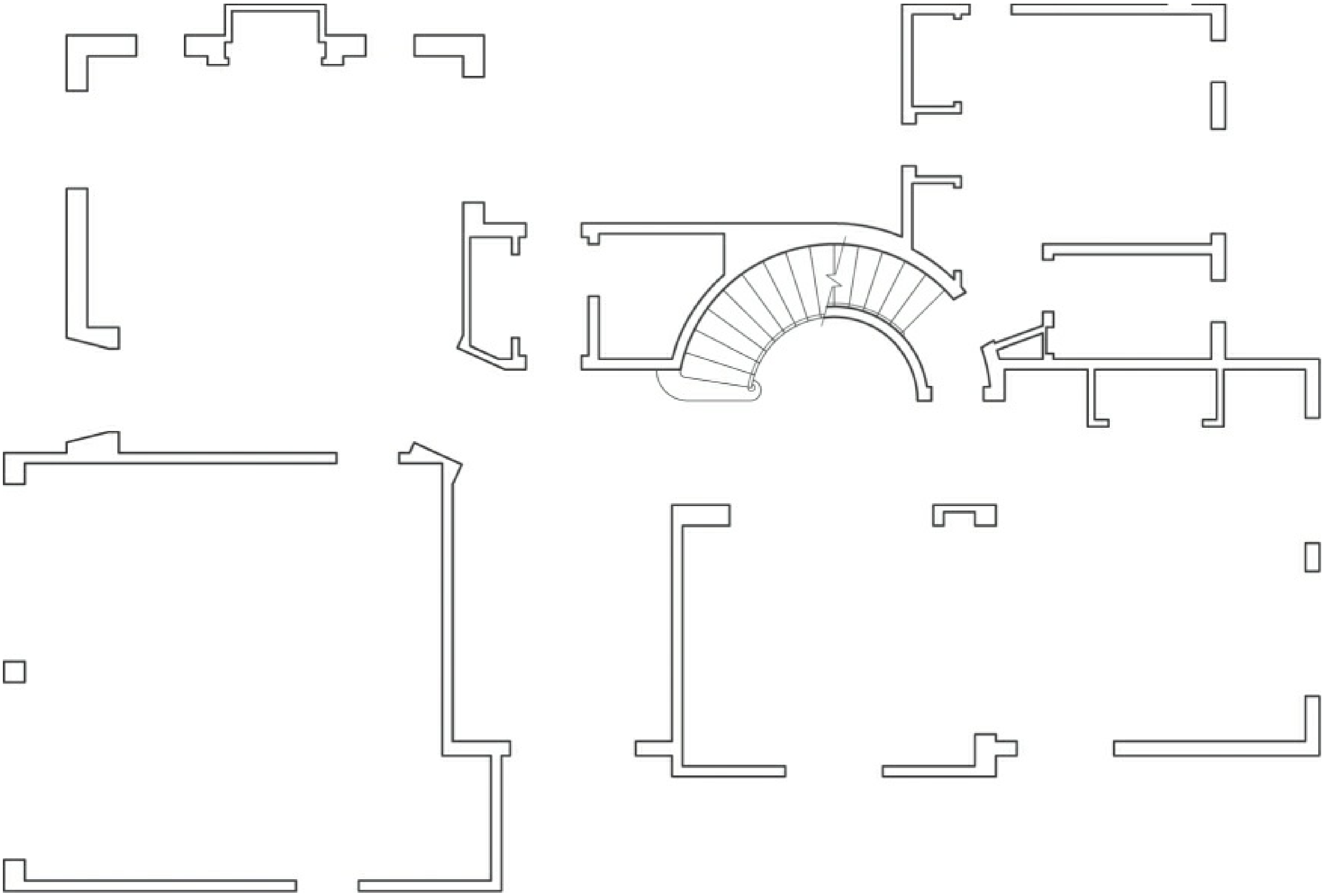


Figure 17.10 Stage II: First‐floor plan.

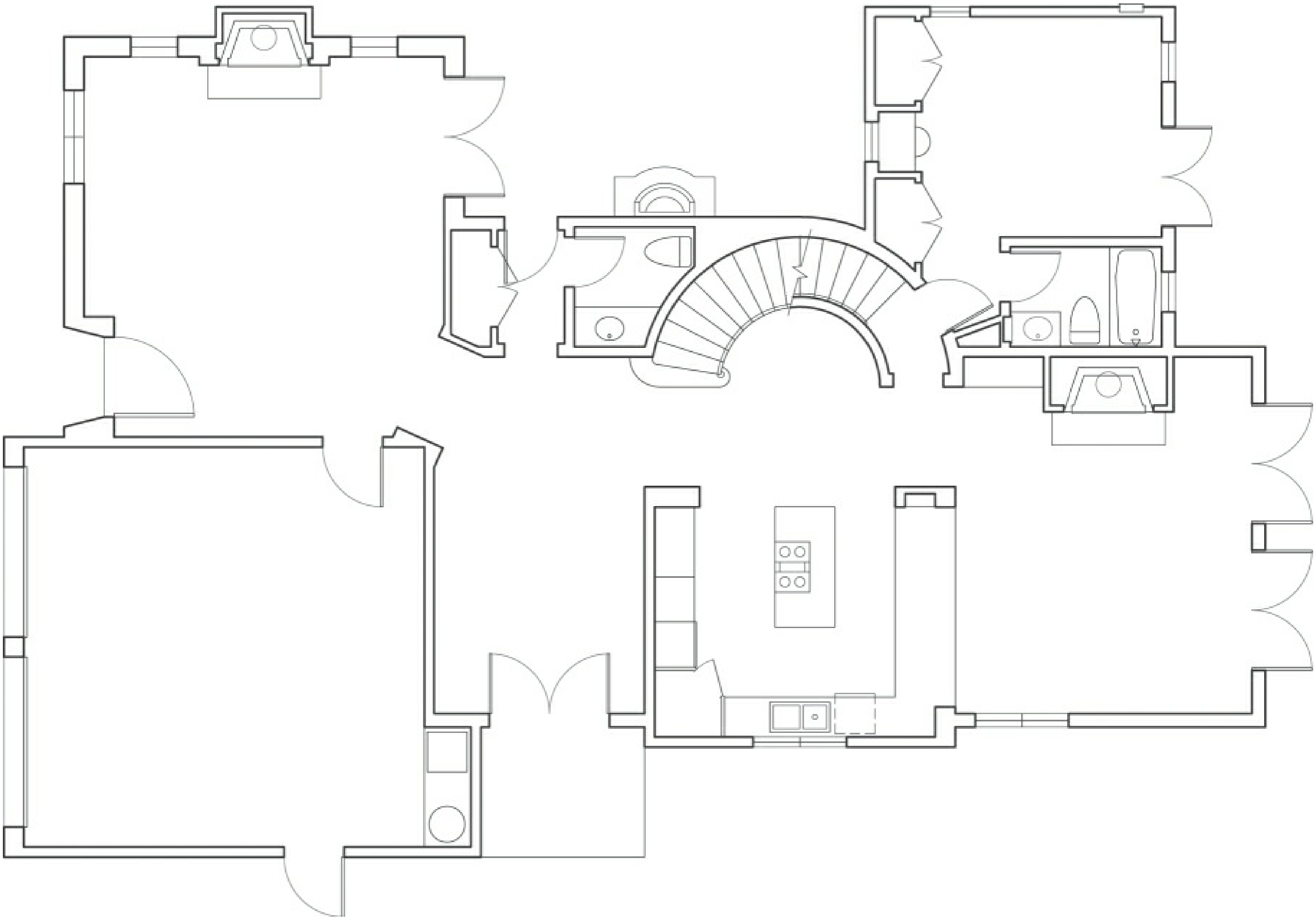
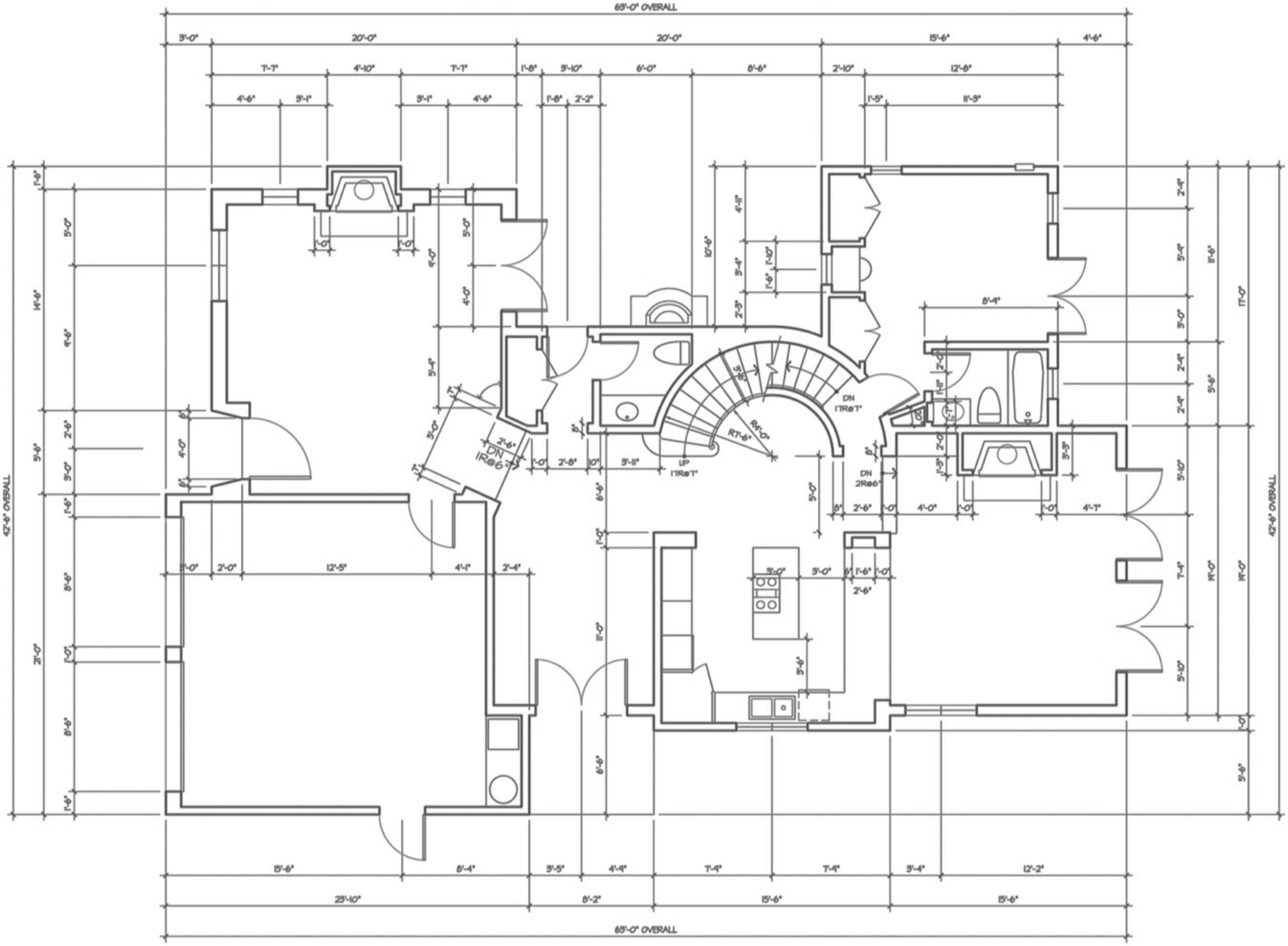


Figure 17.11 Stage III: First…floor plan.



[**Figure 17.12**]() Stage IV: First floor plan.

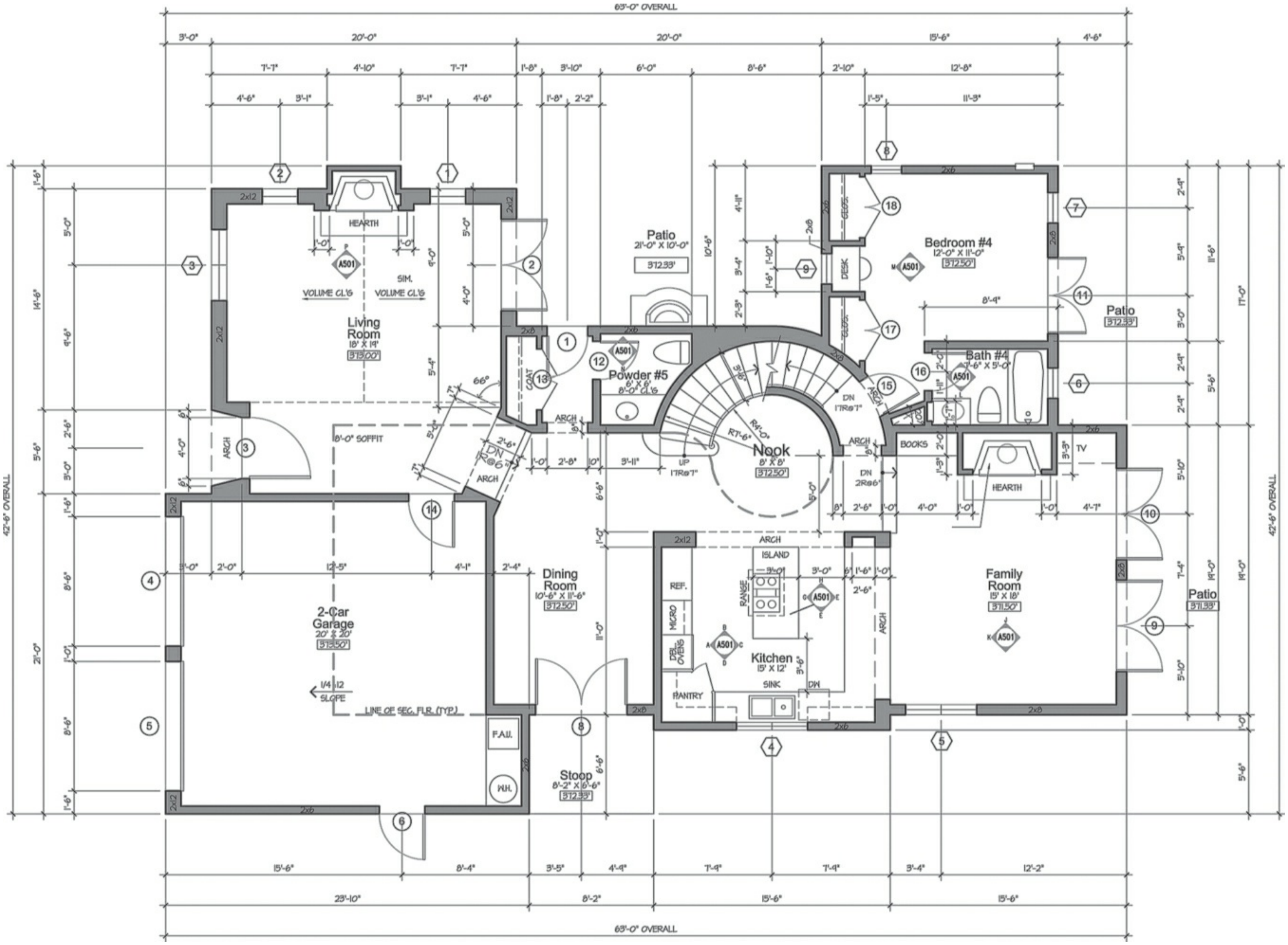


Figure 17.13 Stage V: First…floor plan.

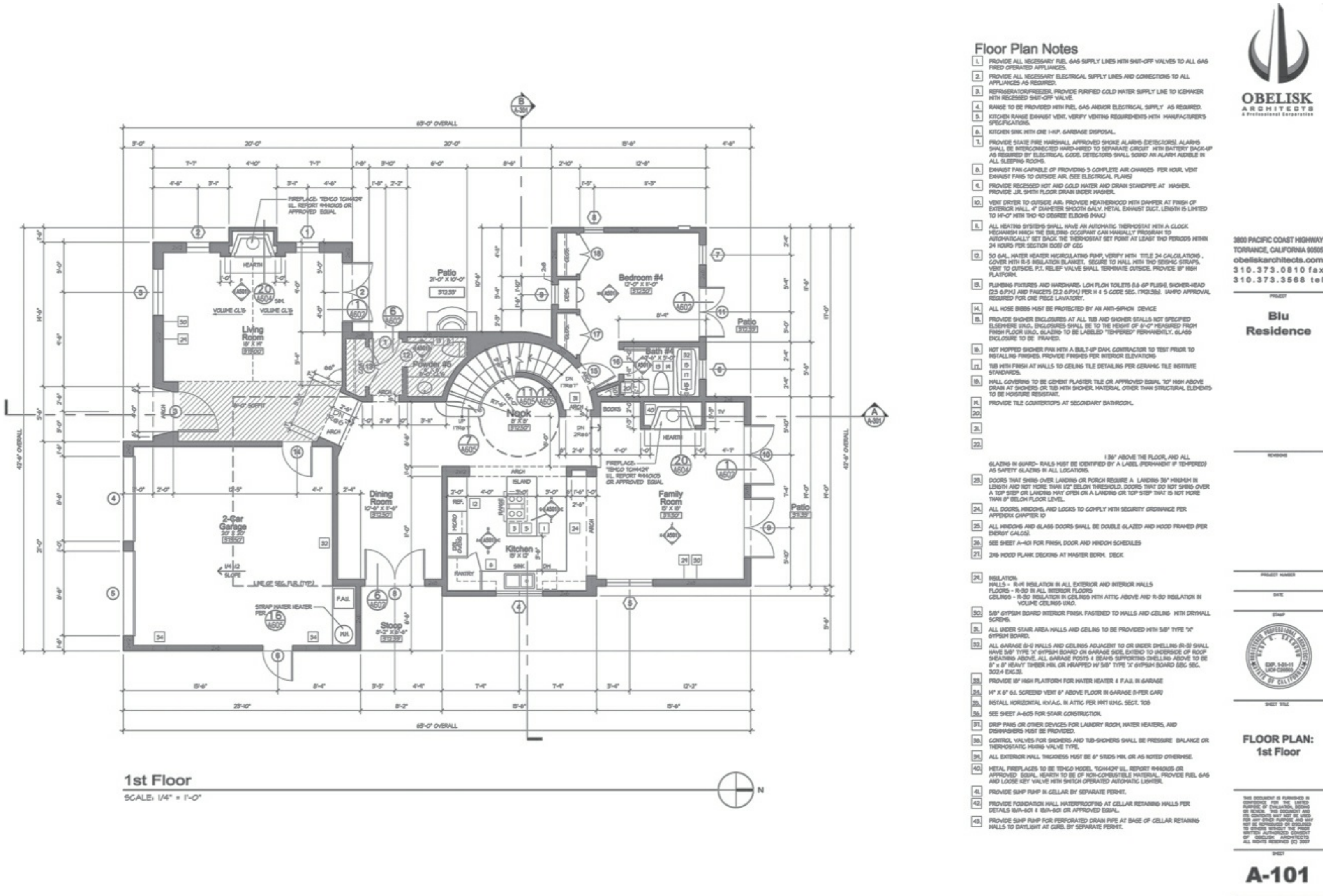


Figure 17.14 Stage VI: First…floor plan.

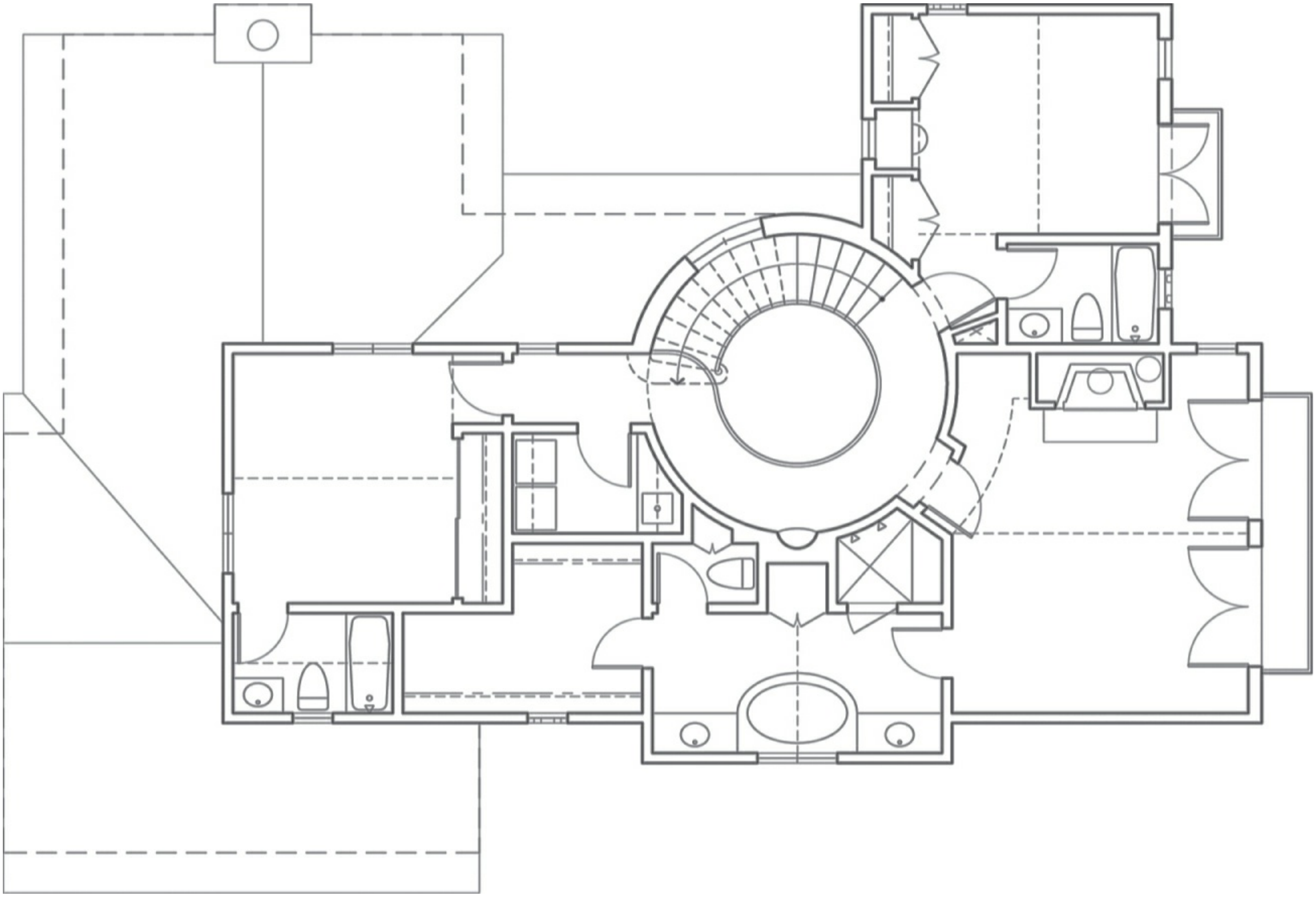
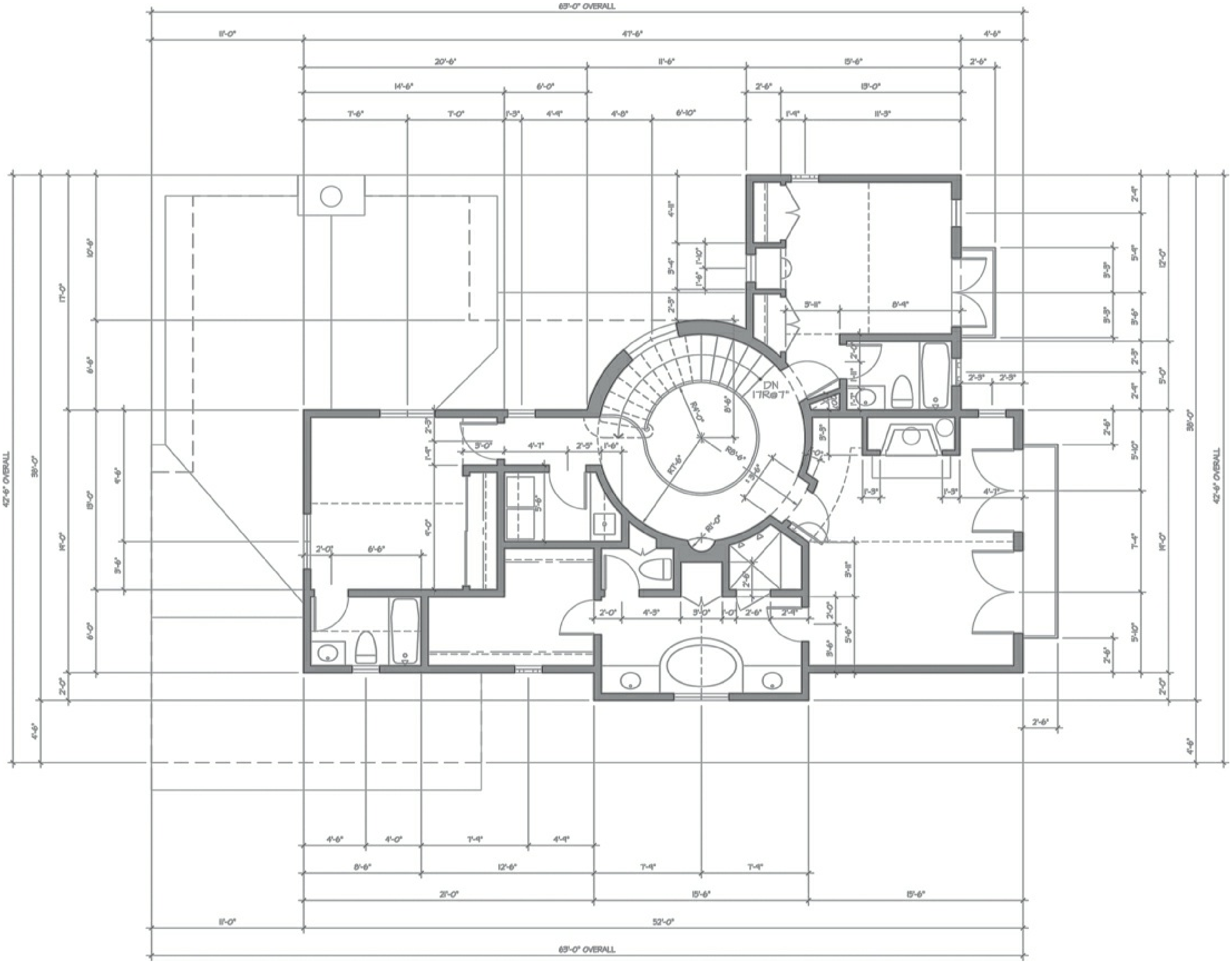


Figure 17.15 Stage II: Second…floor plan.



[**Figure 17.16**]() Stage IV: Second…floor plan.

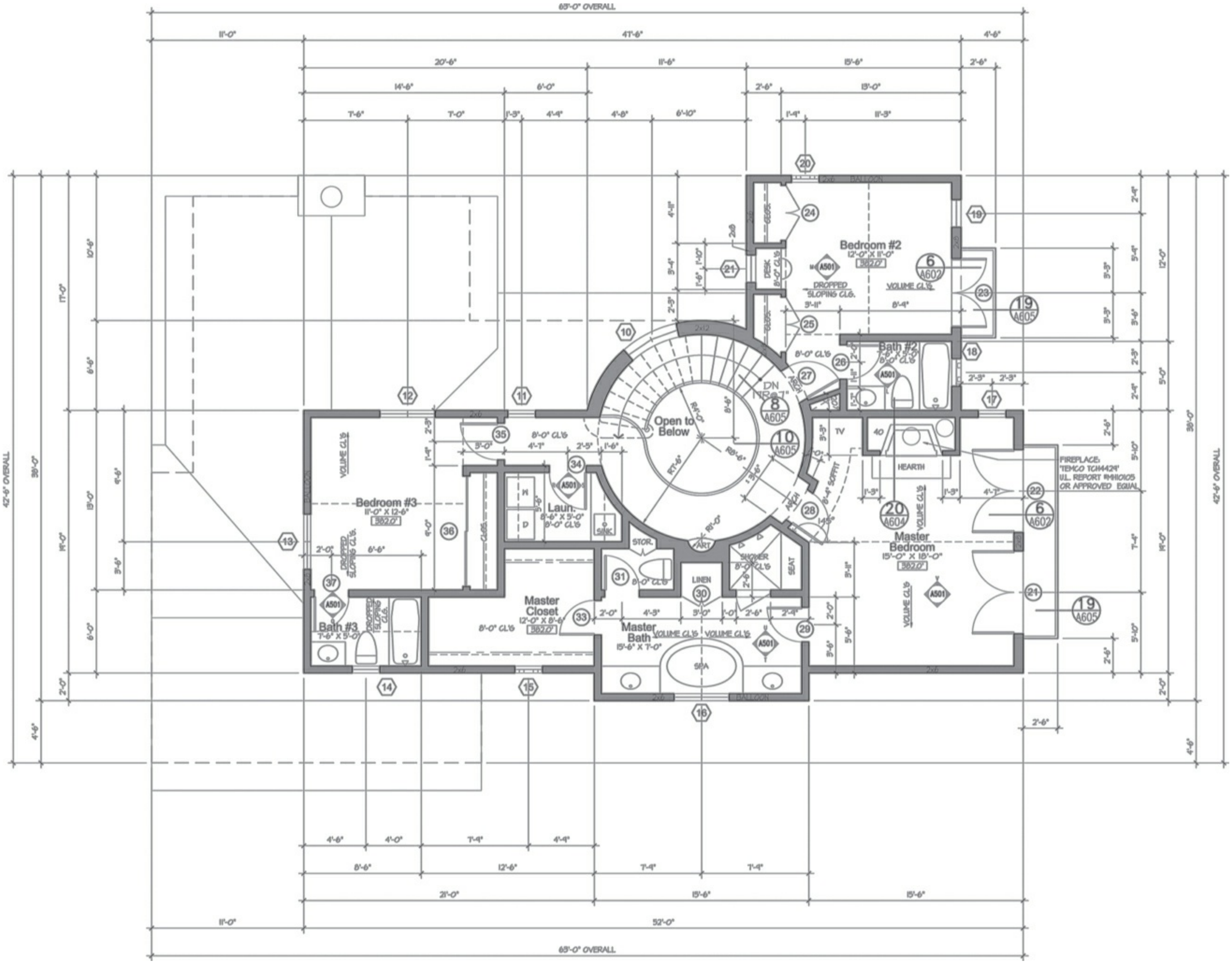


Figure 17.17 Stage V: Second…floor plan.

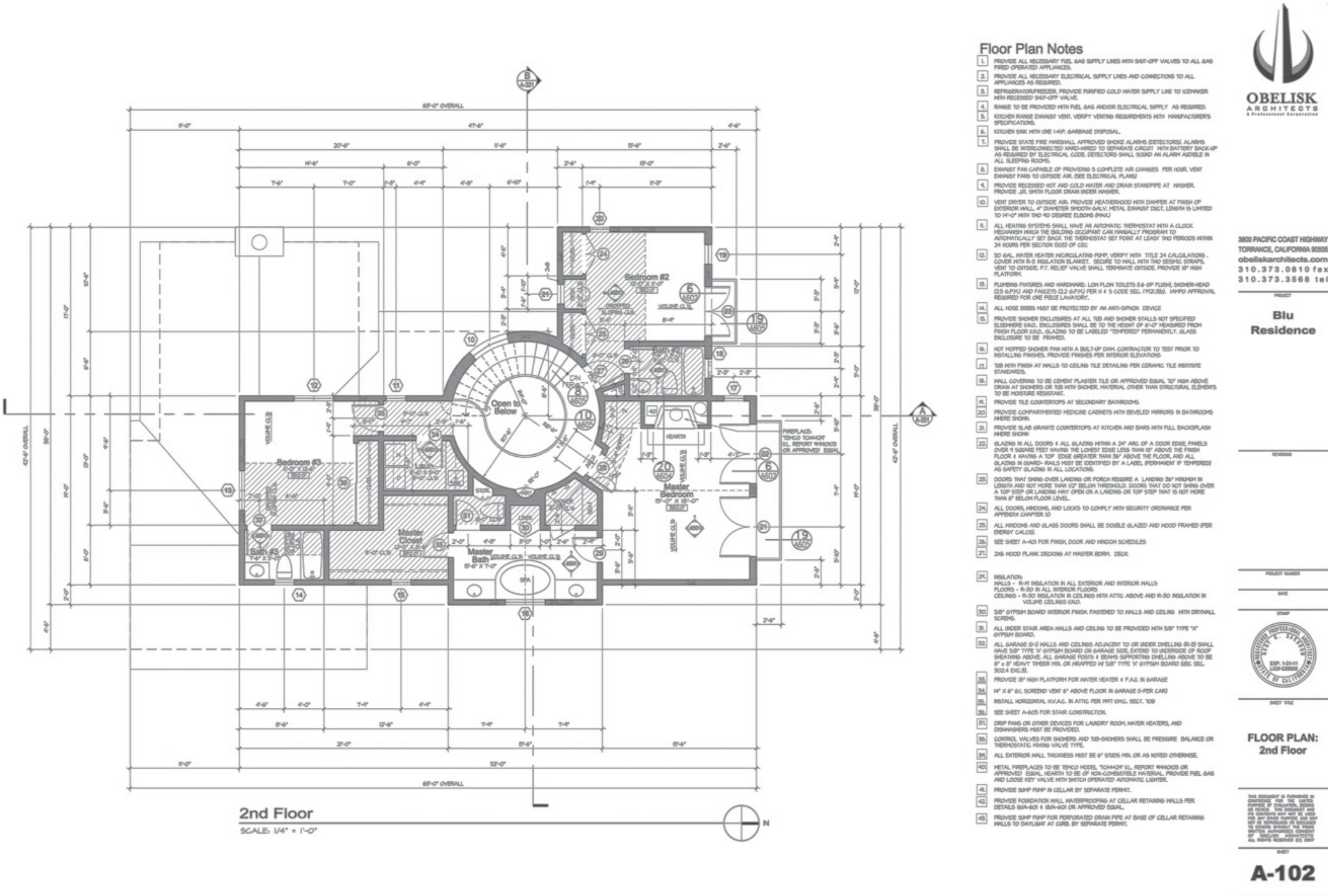


Figure 17.18 Stage VI: Second…floor plan.

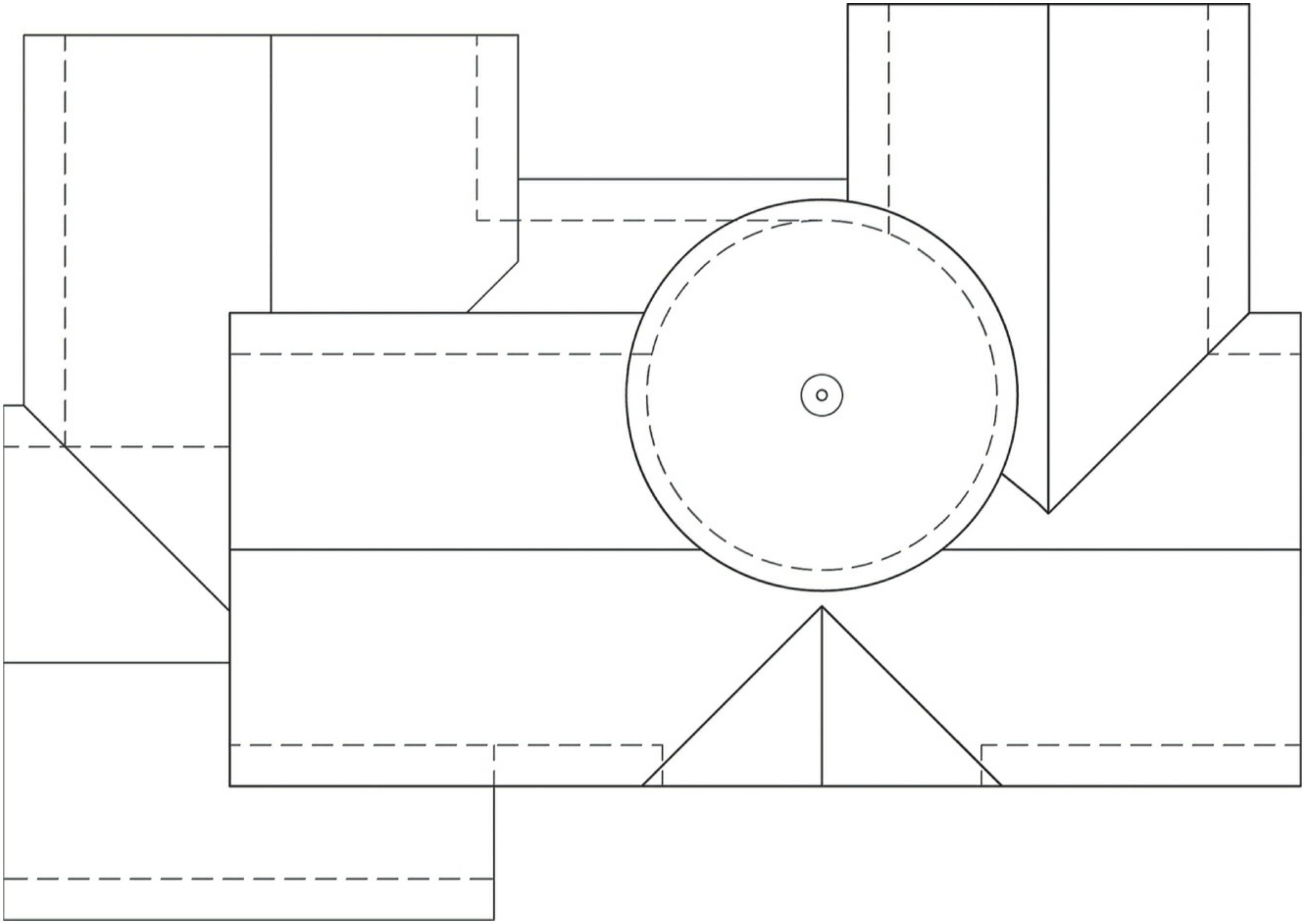


Figure 17.19 Stage I: Roof plan.

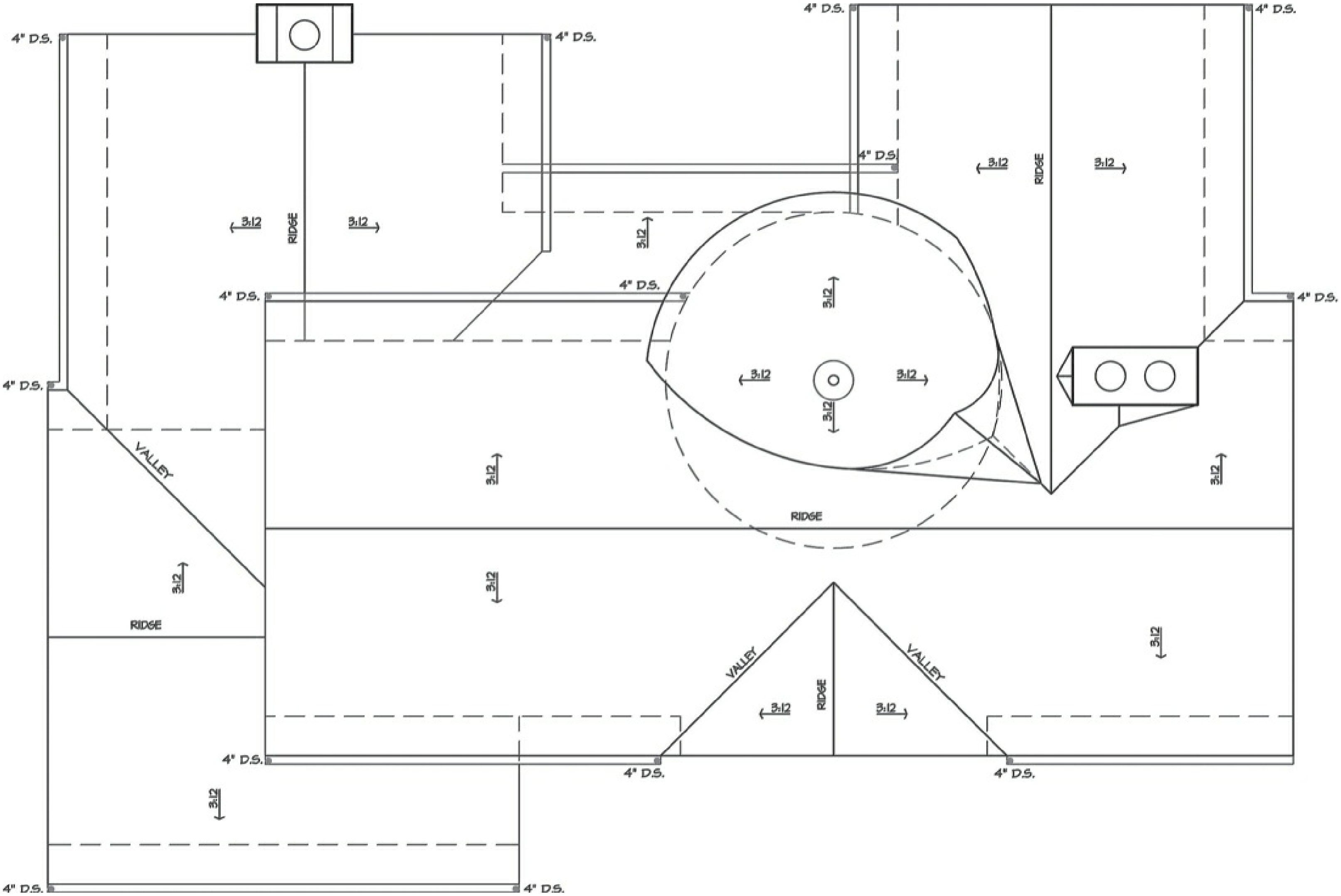


Figure 17.20 Stage II: Roof plan.

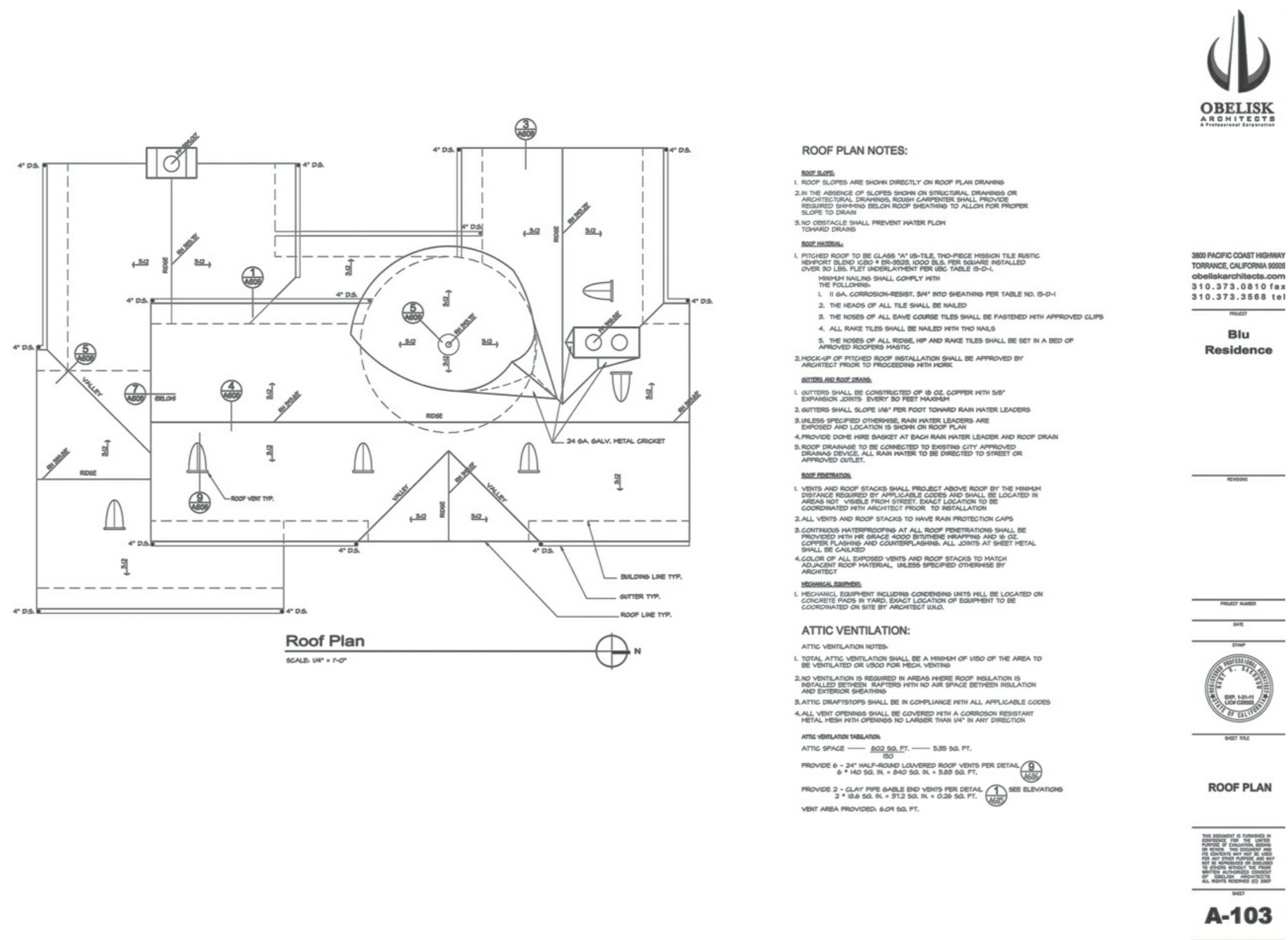
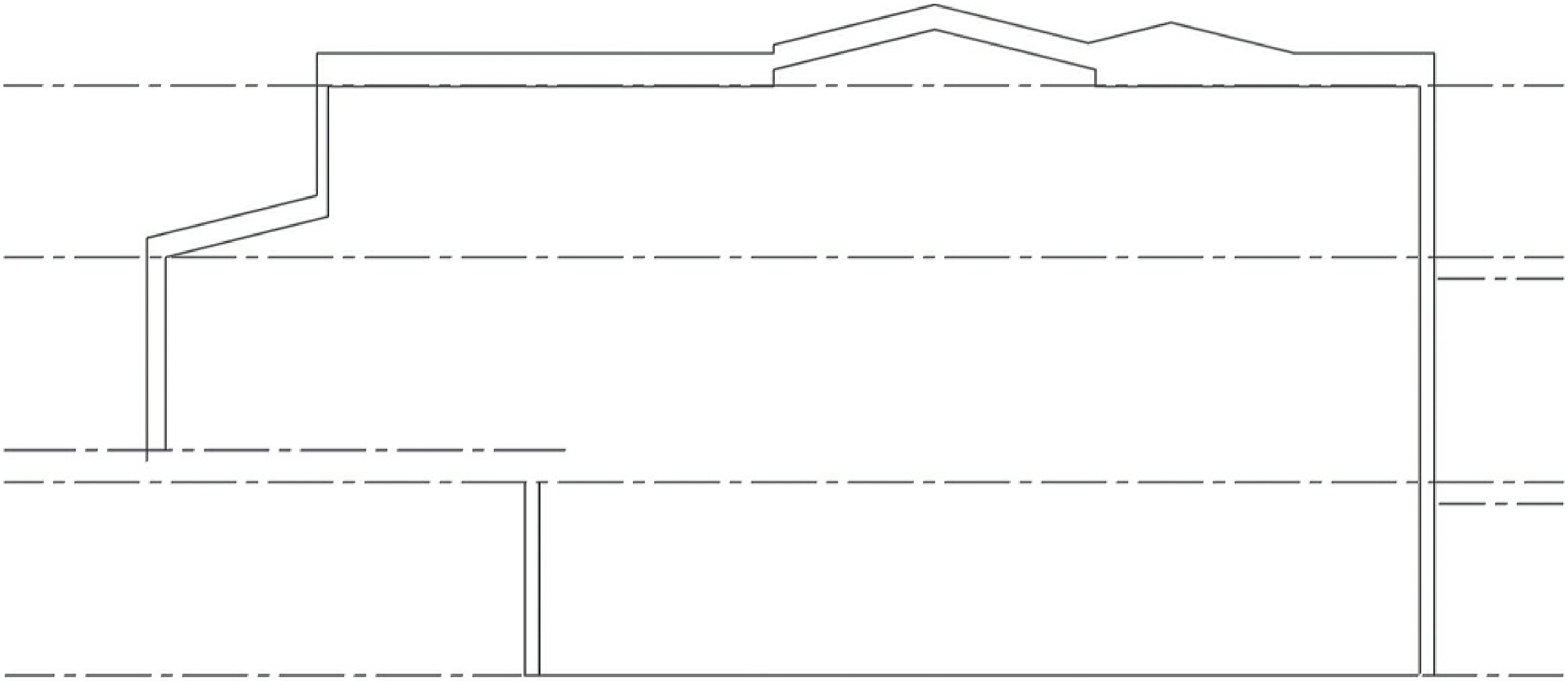


Figure 17.21 Stage III: Roof plan.

Figure 17.22 Stage I: Building section.



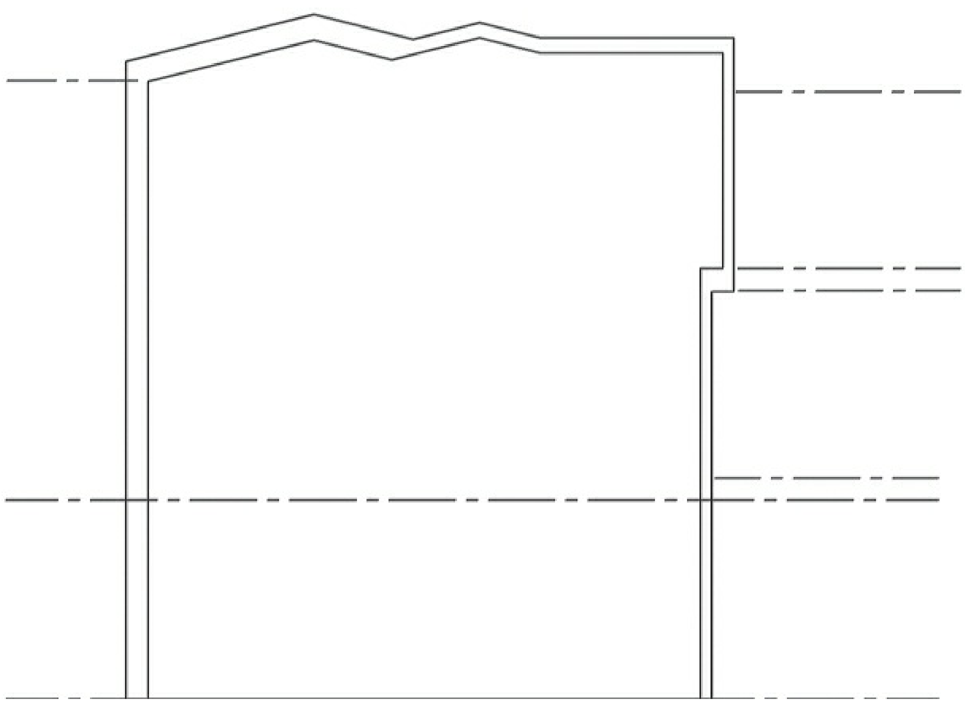


Figure 17.23 Stage II: Building section.

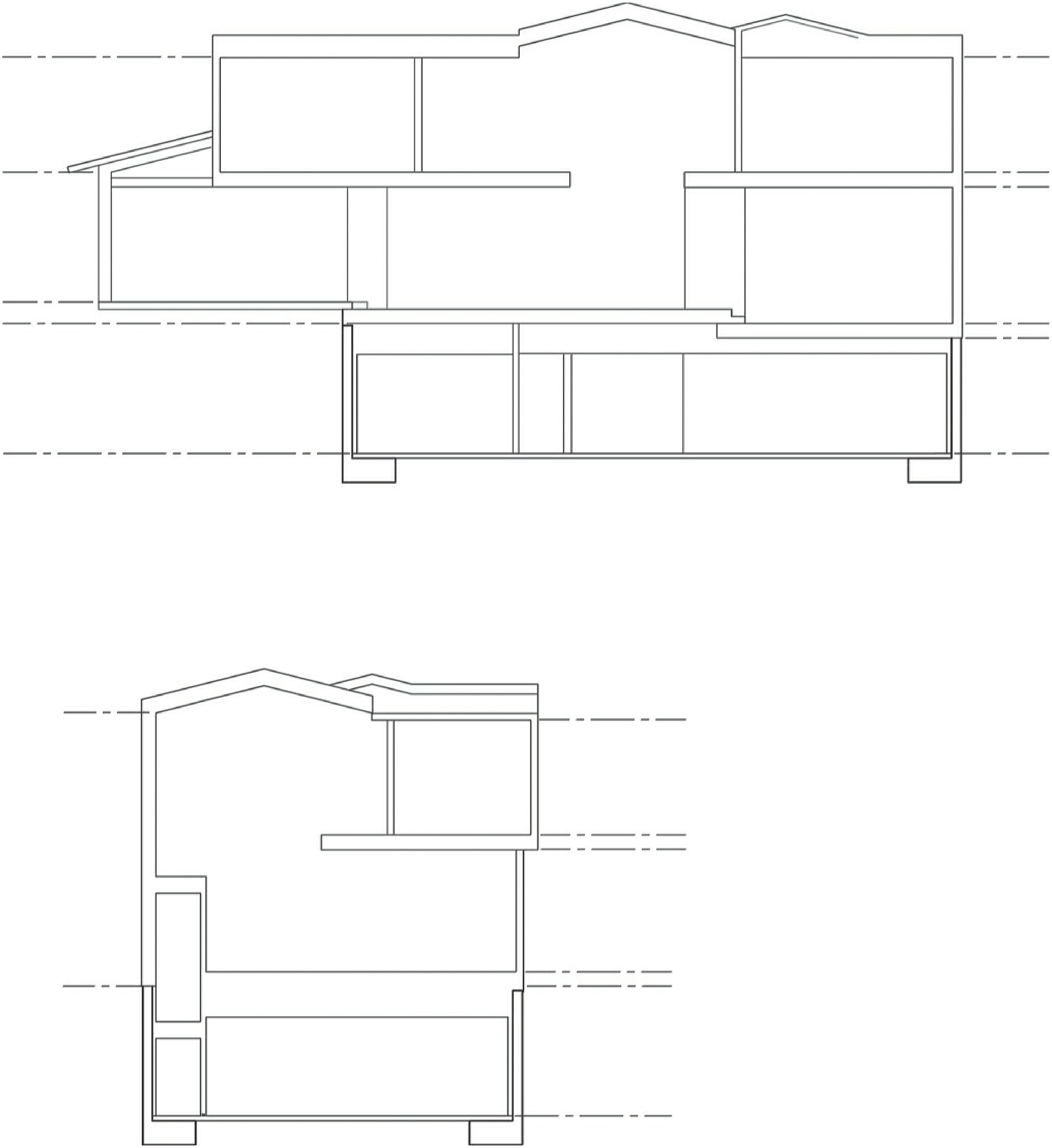


Figure 17.24 Stage III: Building section.

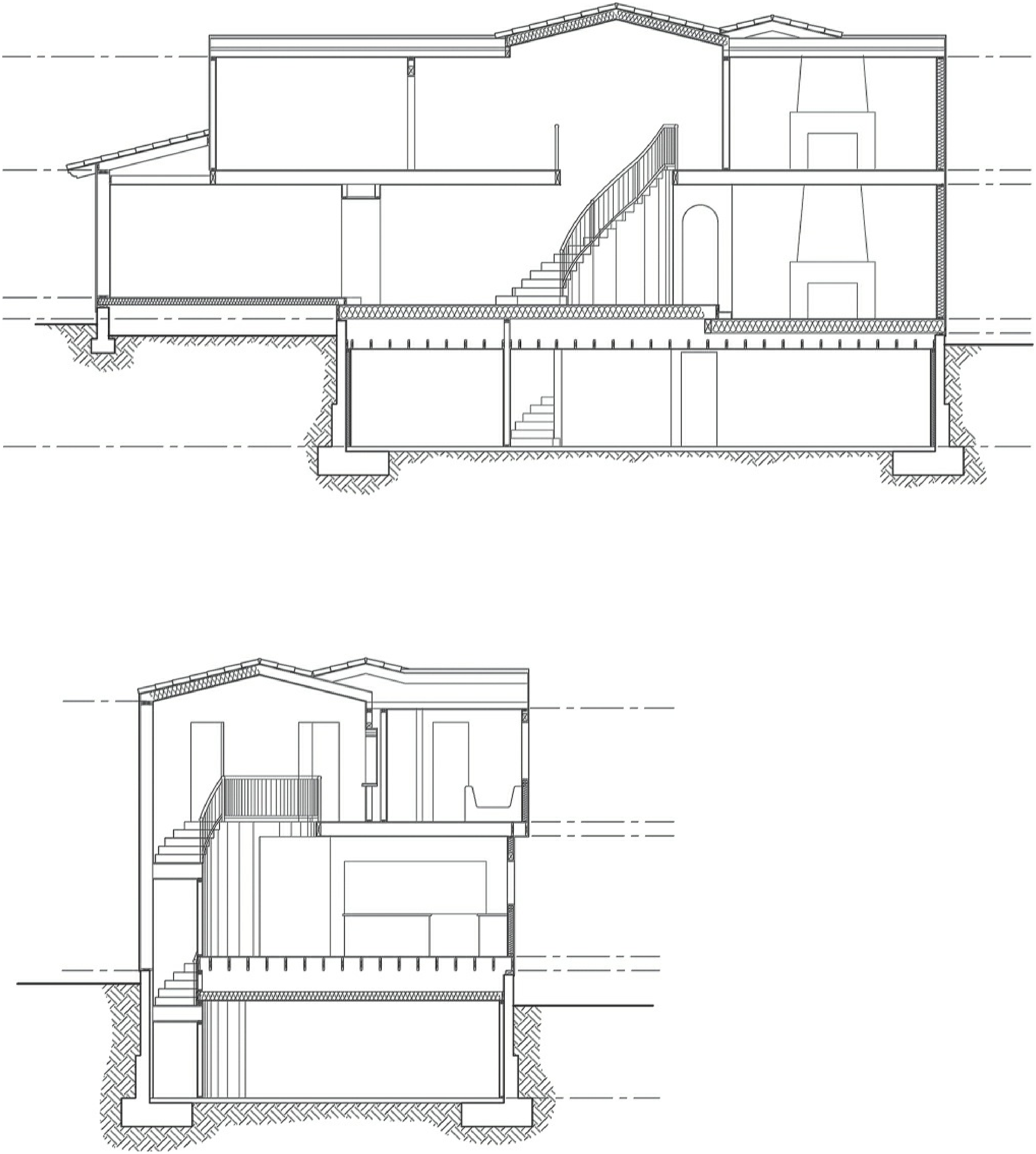
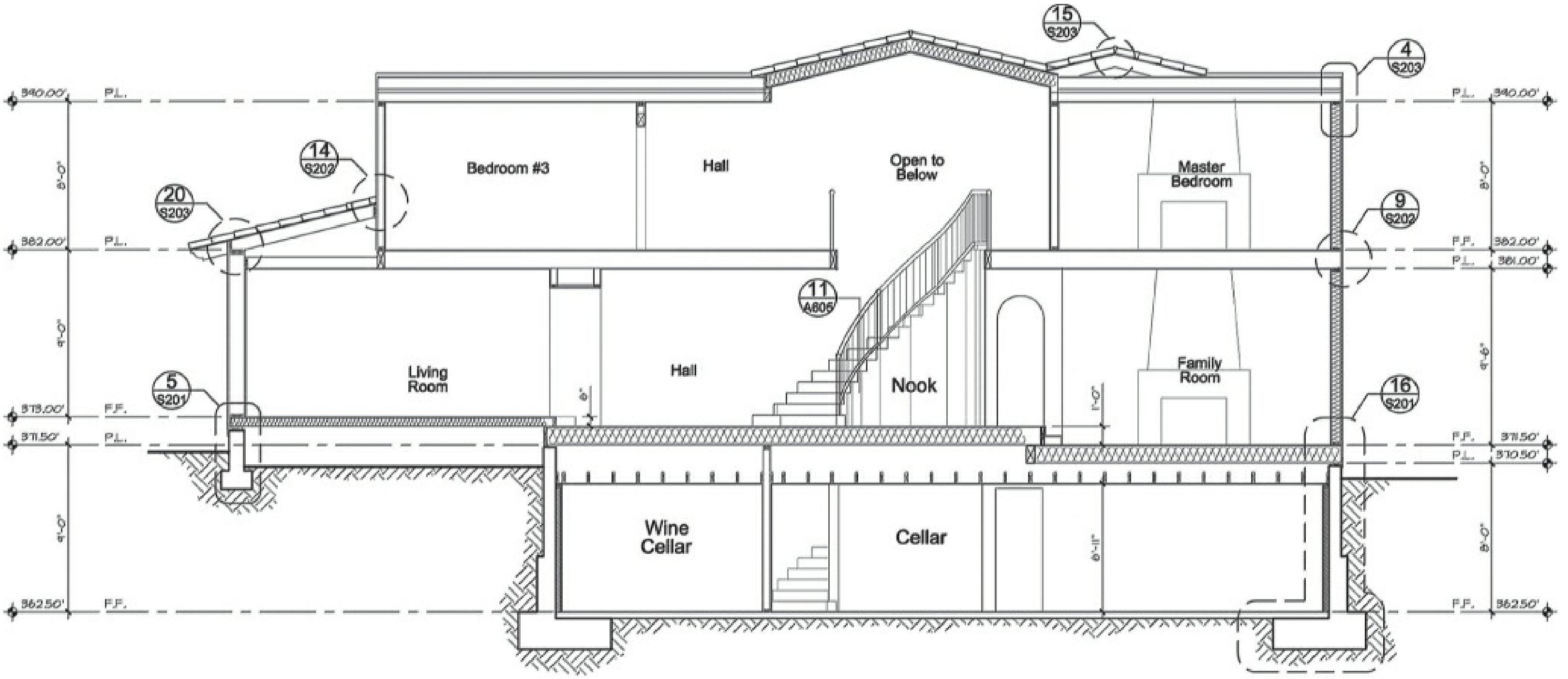


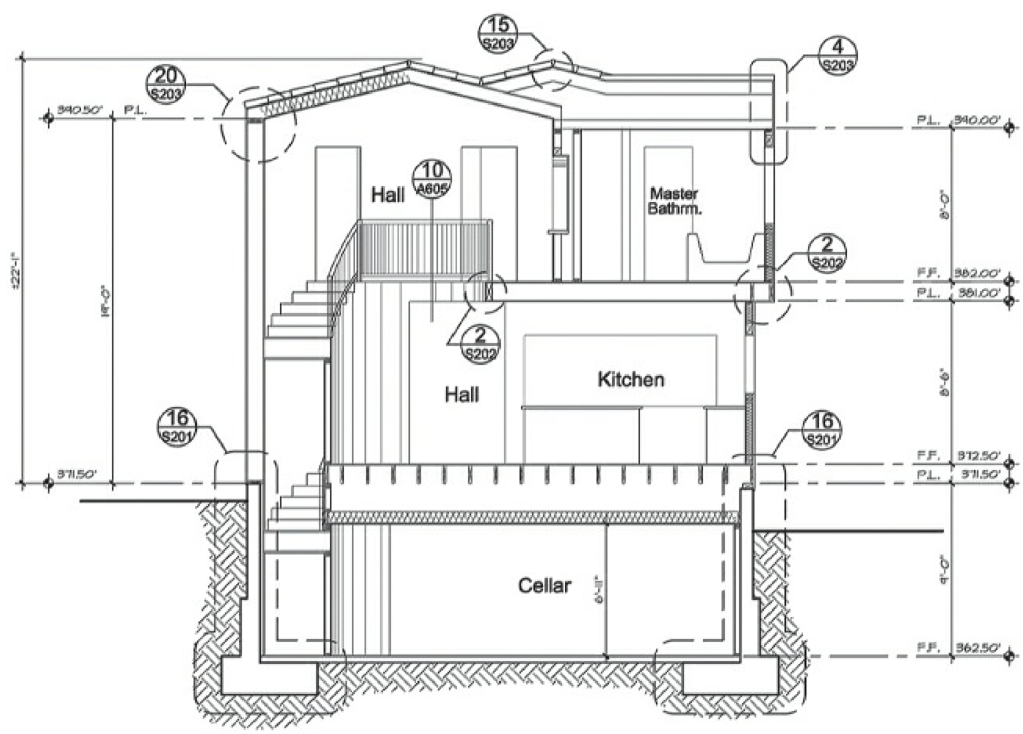
Figure 17.25 Stage IV: Building section.



Building Section "A"

SCALE: 1/4" = 1'-0"

SECTION NOTES:



Building Section "B"

SCALE: 1/4" = 1'-0"

Figure 17.26 Stage V: Building section.

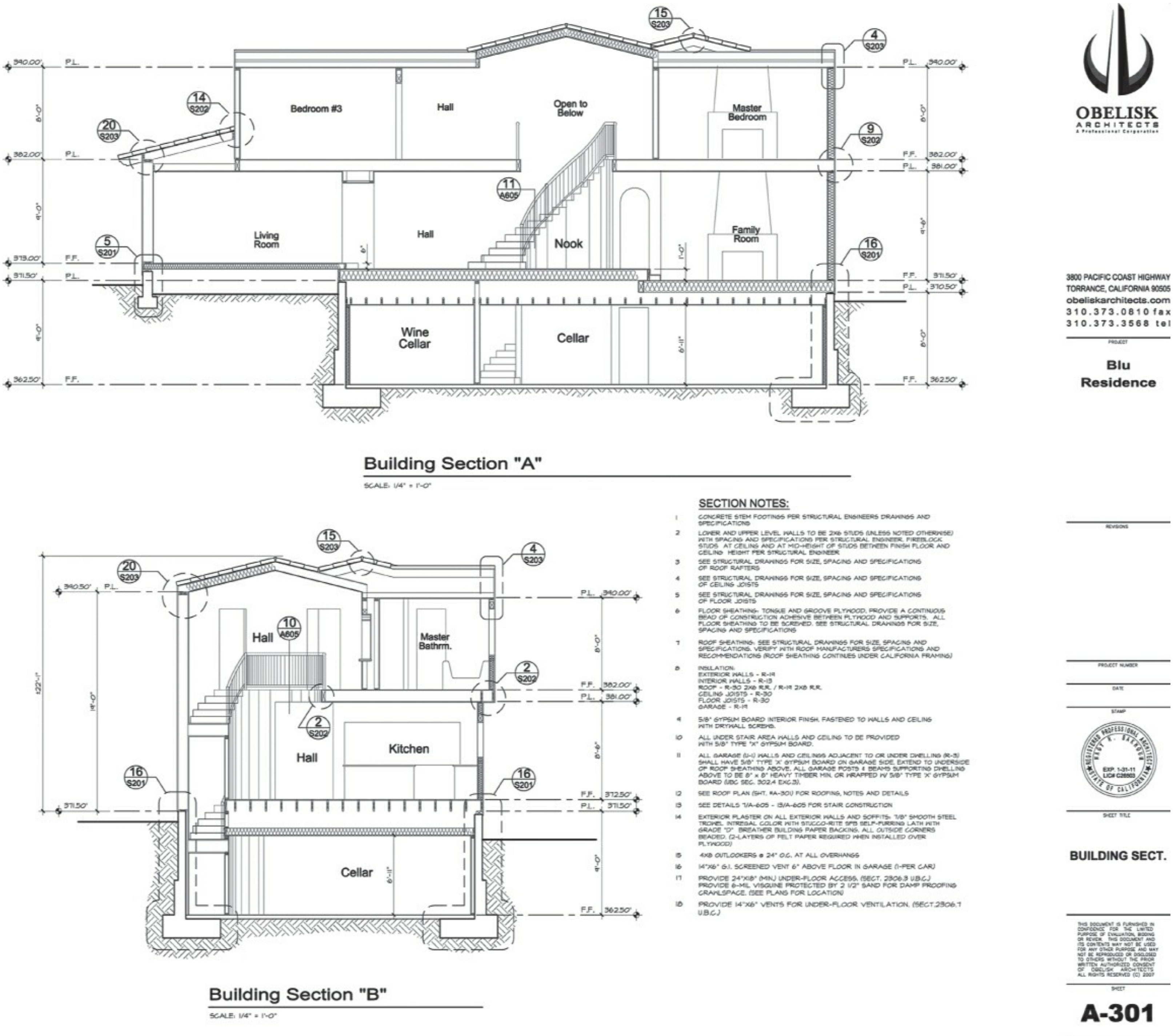
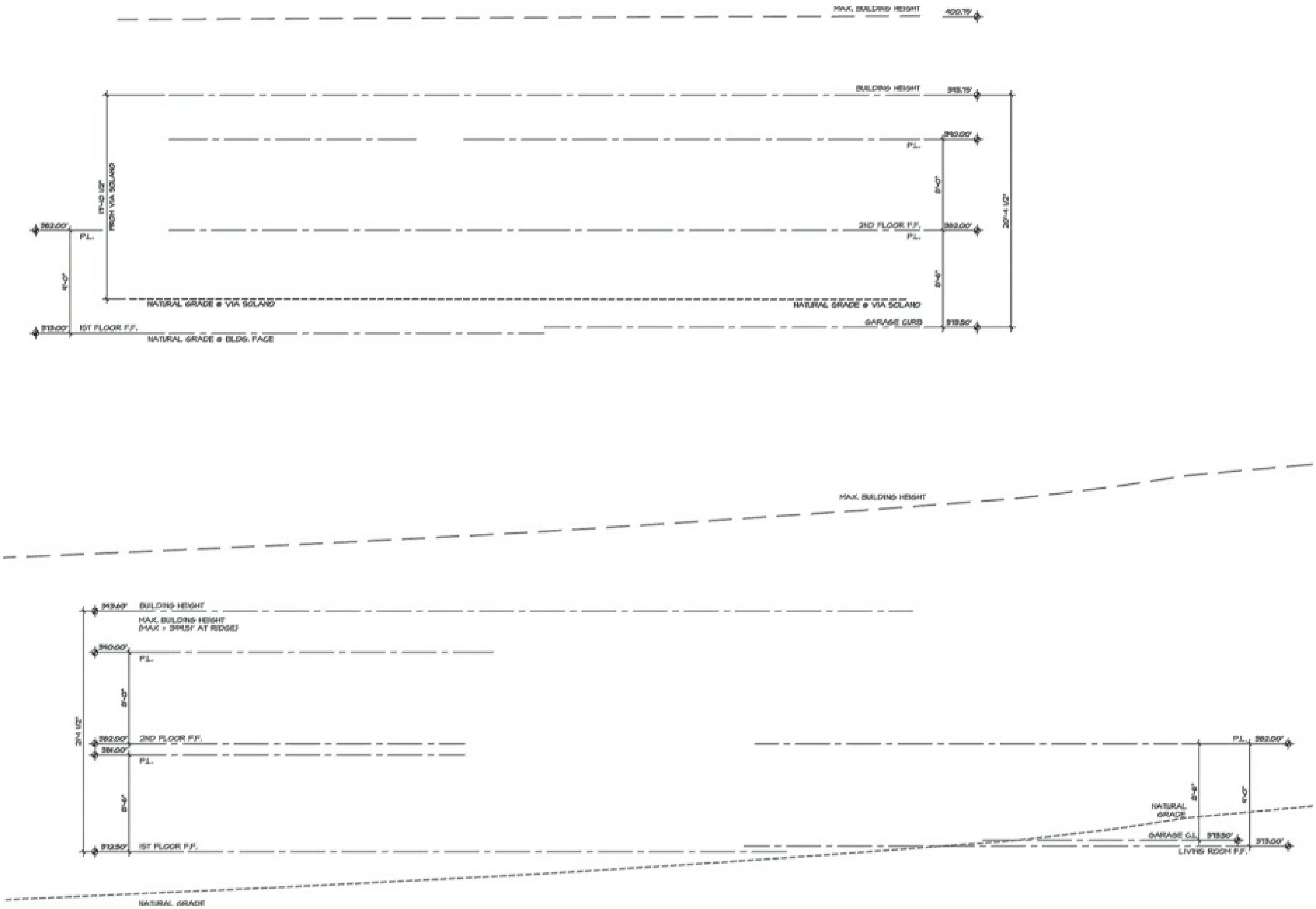


Figure 17.27 Stage VI: Building section.



[Figure 17.28](#) Stage I: Building elevations.

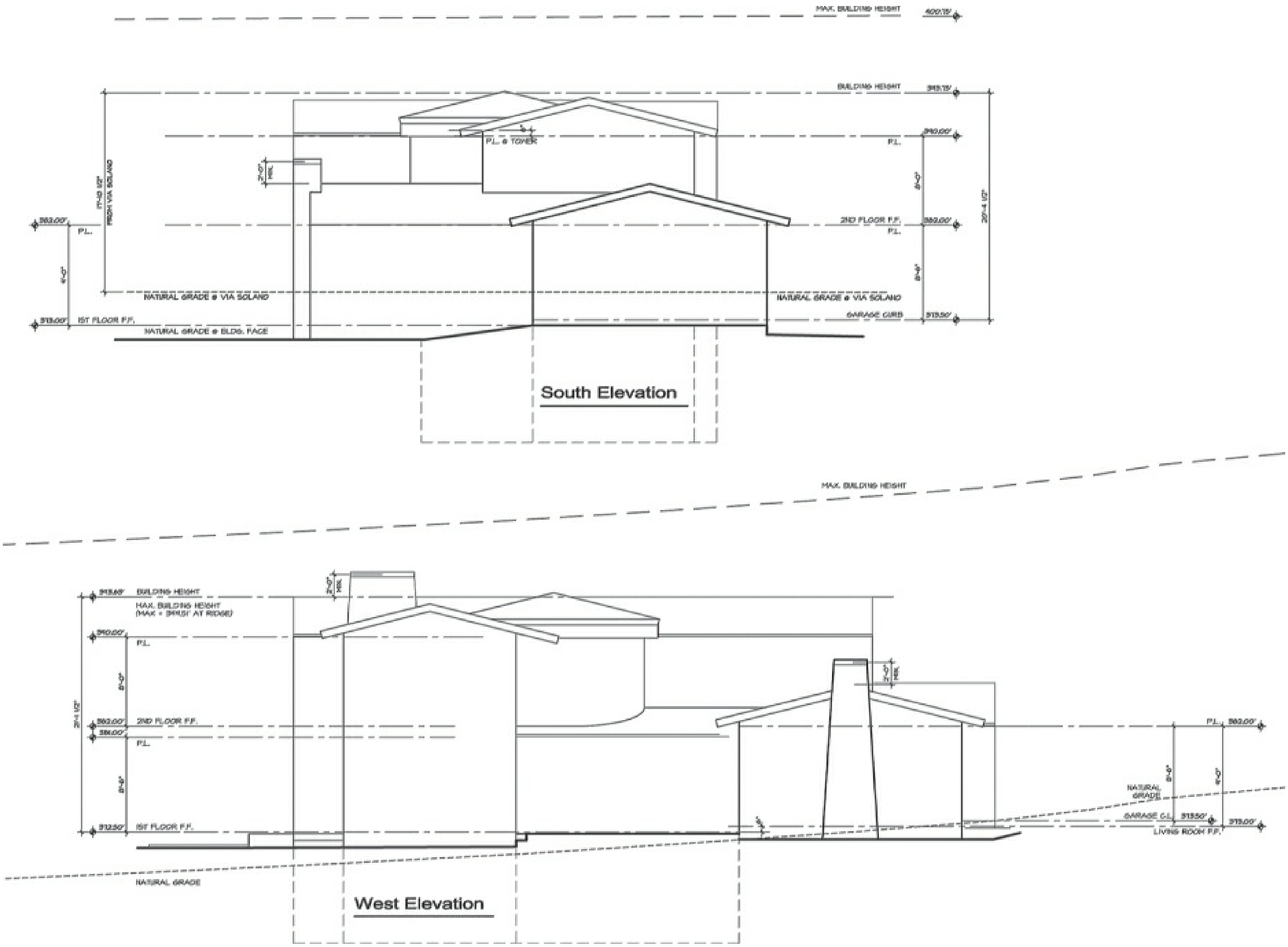
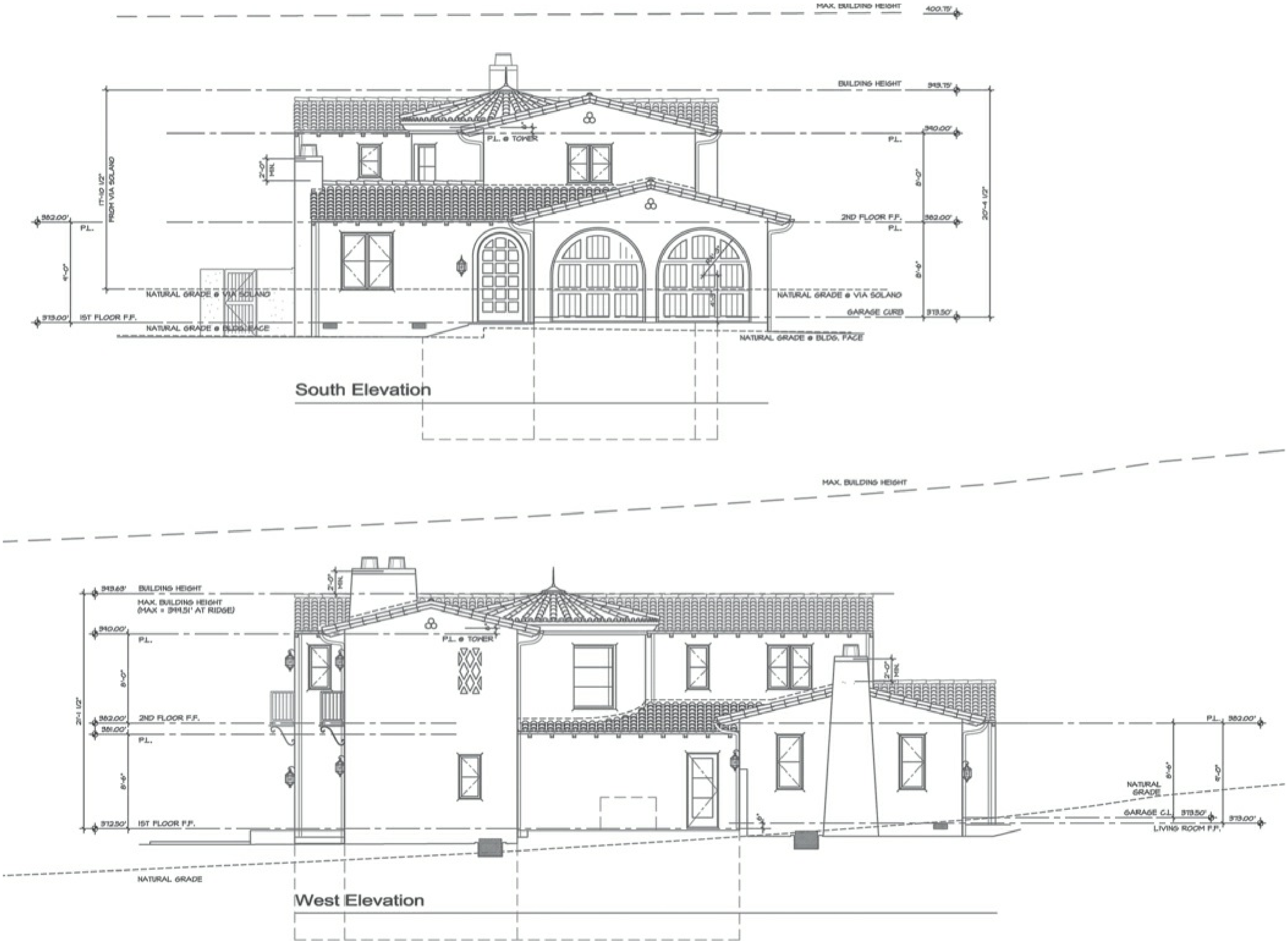


Figure 17.29 Stage II: Building section and elevations.



[**Figure 17.30**]() Stage III: Building section and elevations.

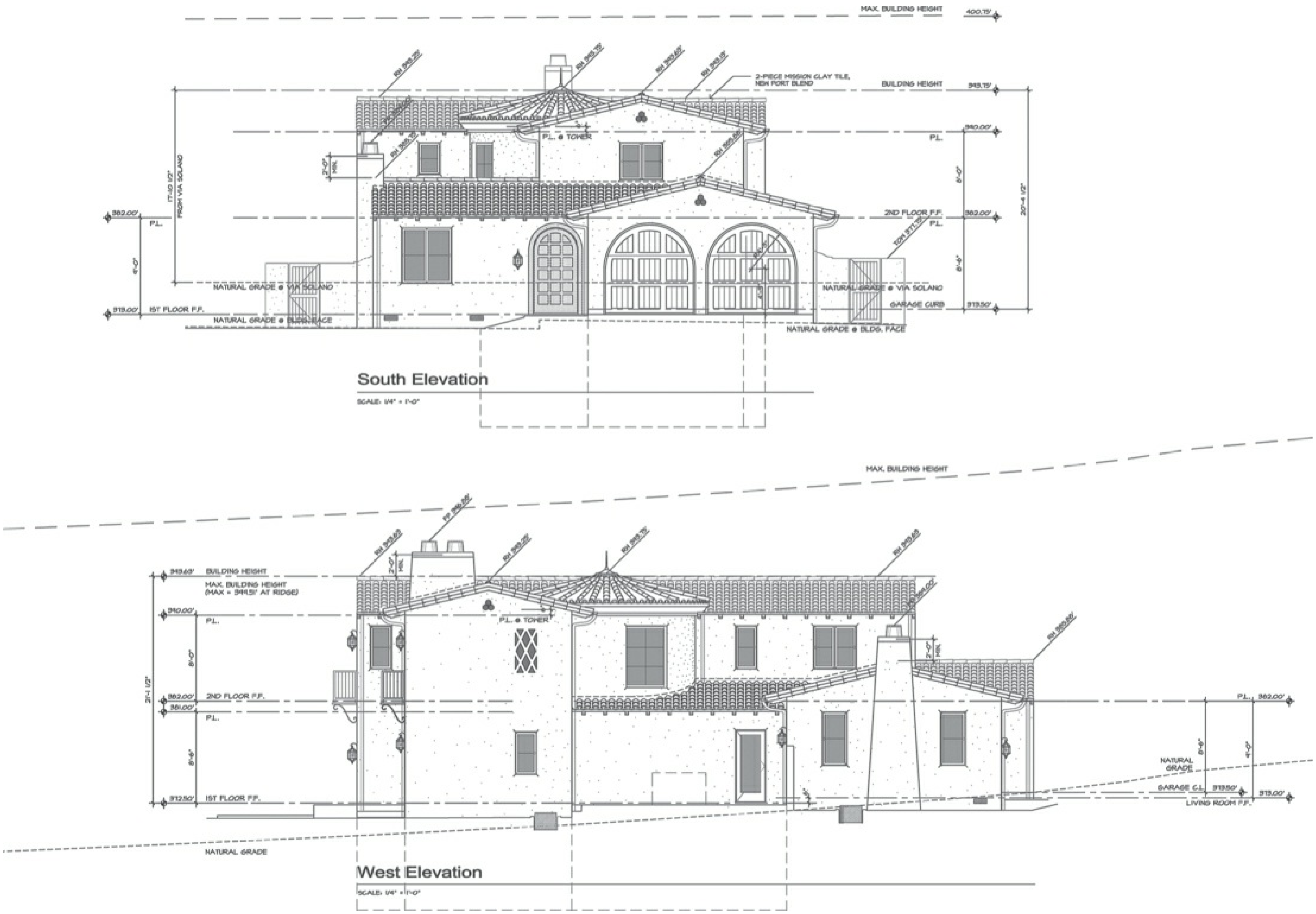


Figure 17.31 Stage IV: Building elevations.

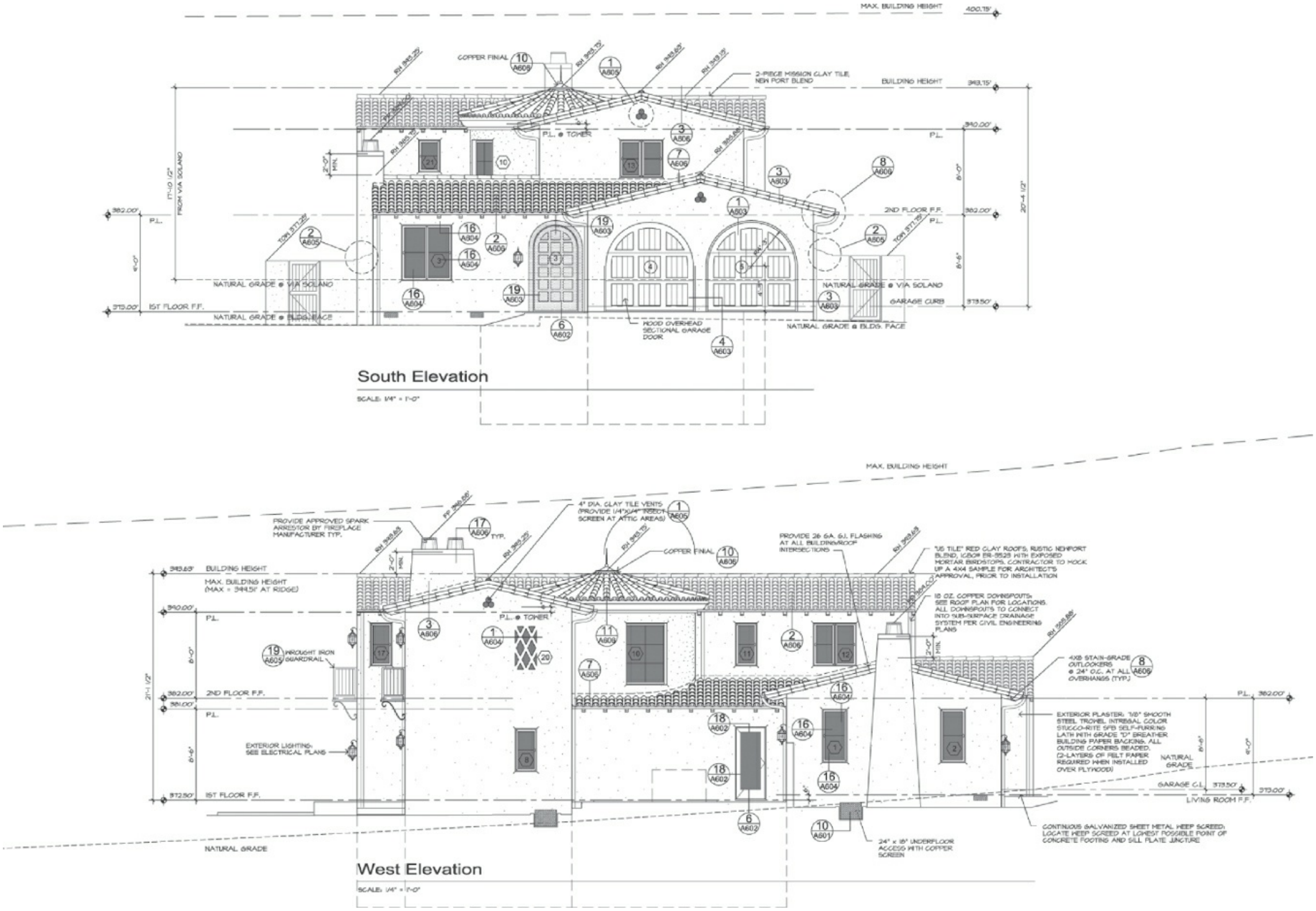
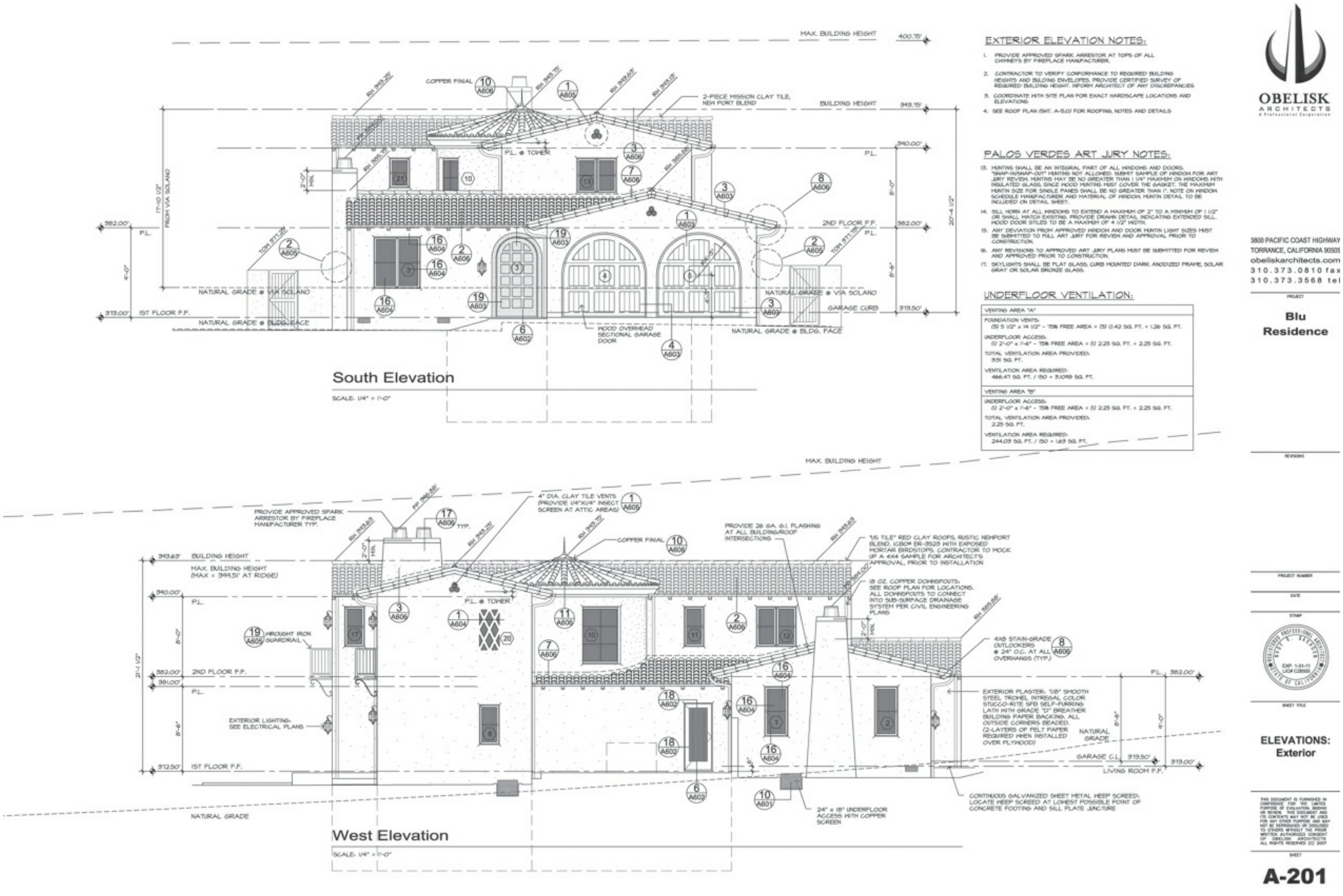


Figure 17.32 Stage V: Building elevations.



[Figure 17.33](#) Stage VI: Building elevations.

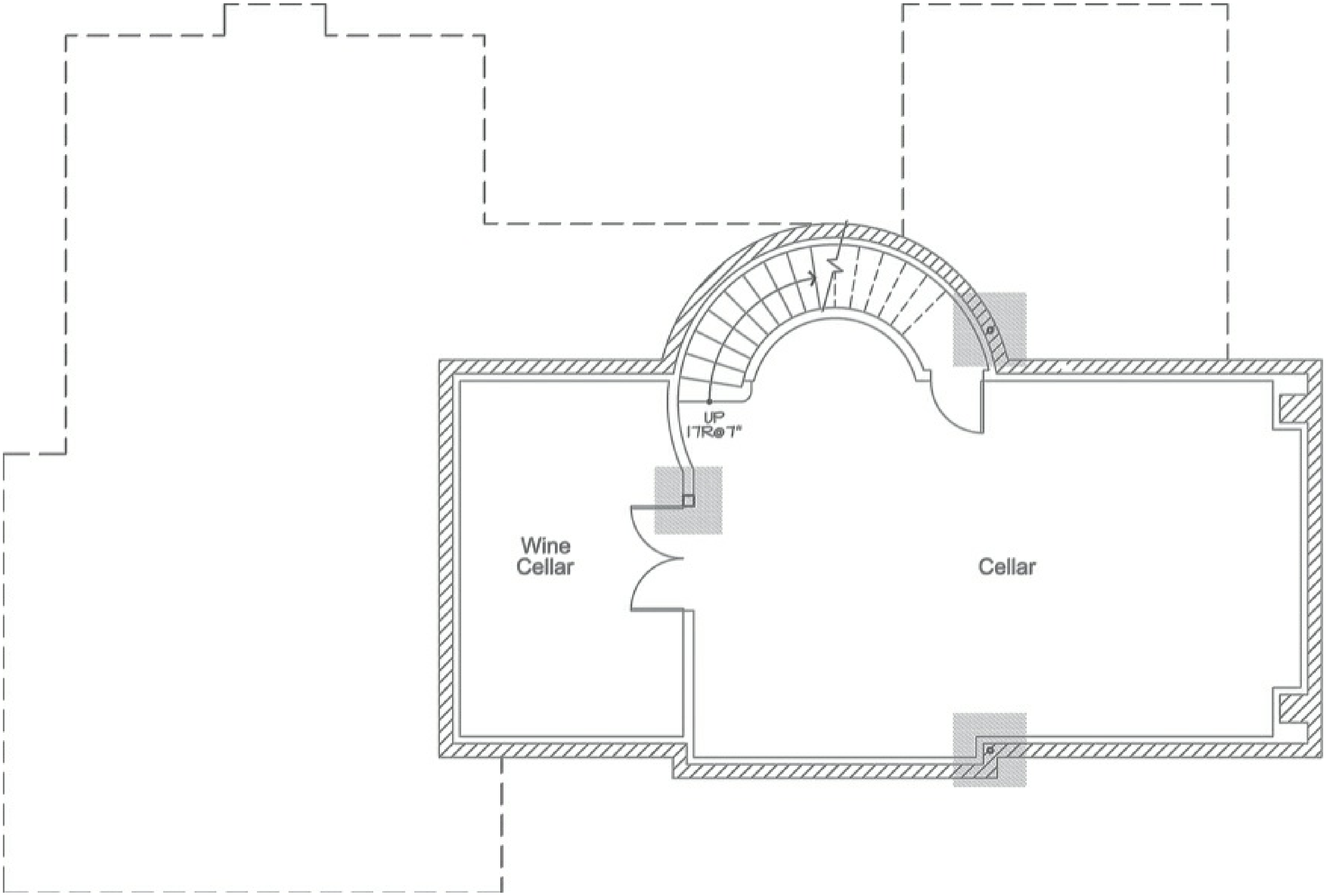


Figure 17.34 Stage II: Foundation plan (slab).

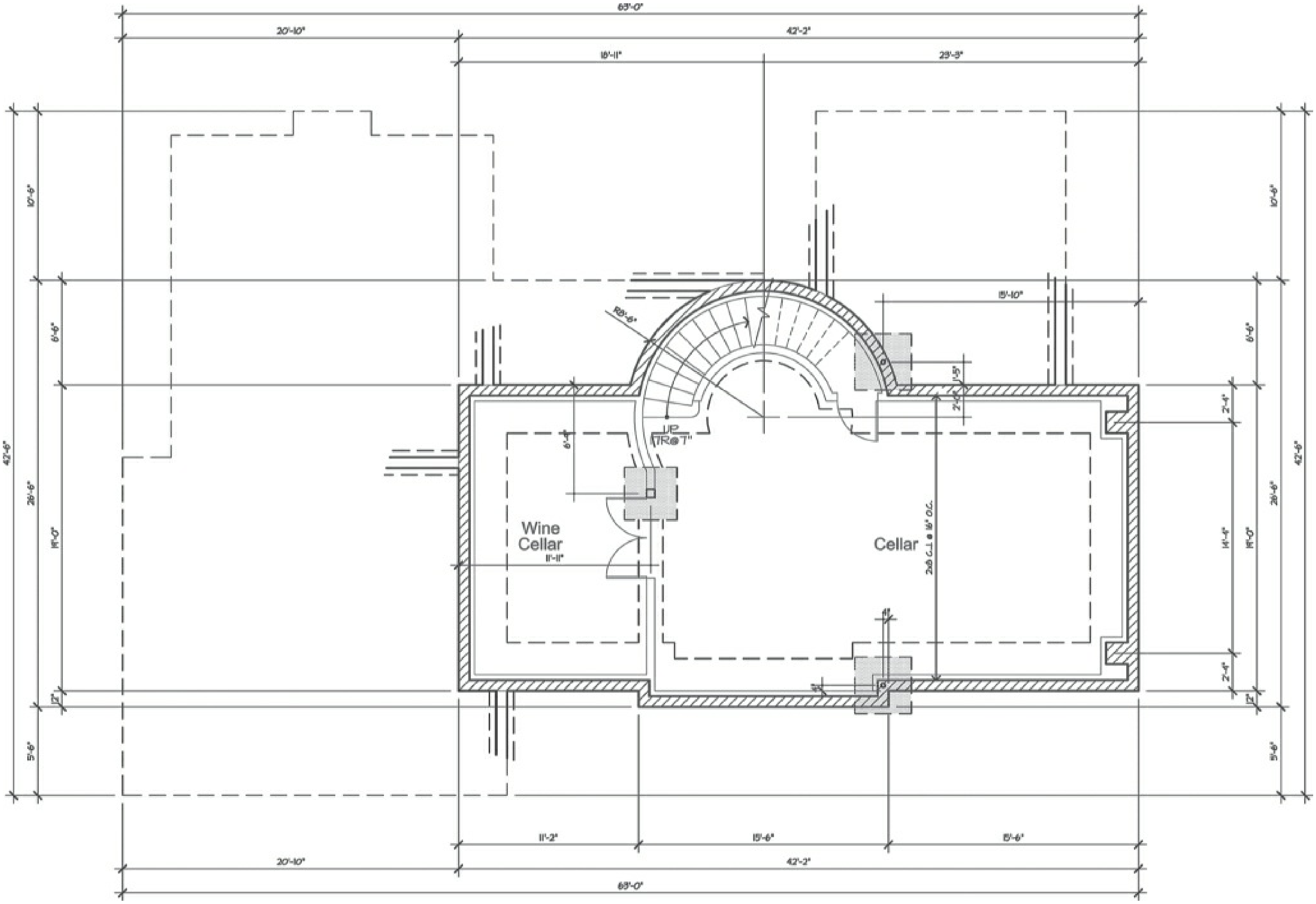


Figure 17.35 Stage III: Foundation plan.

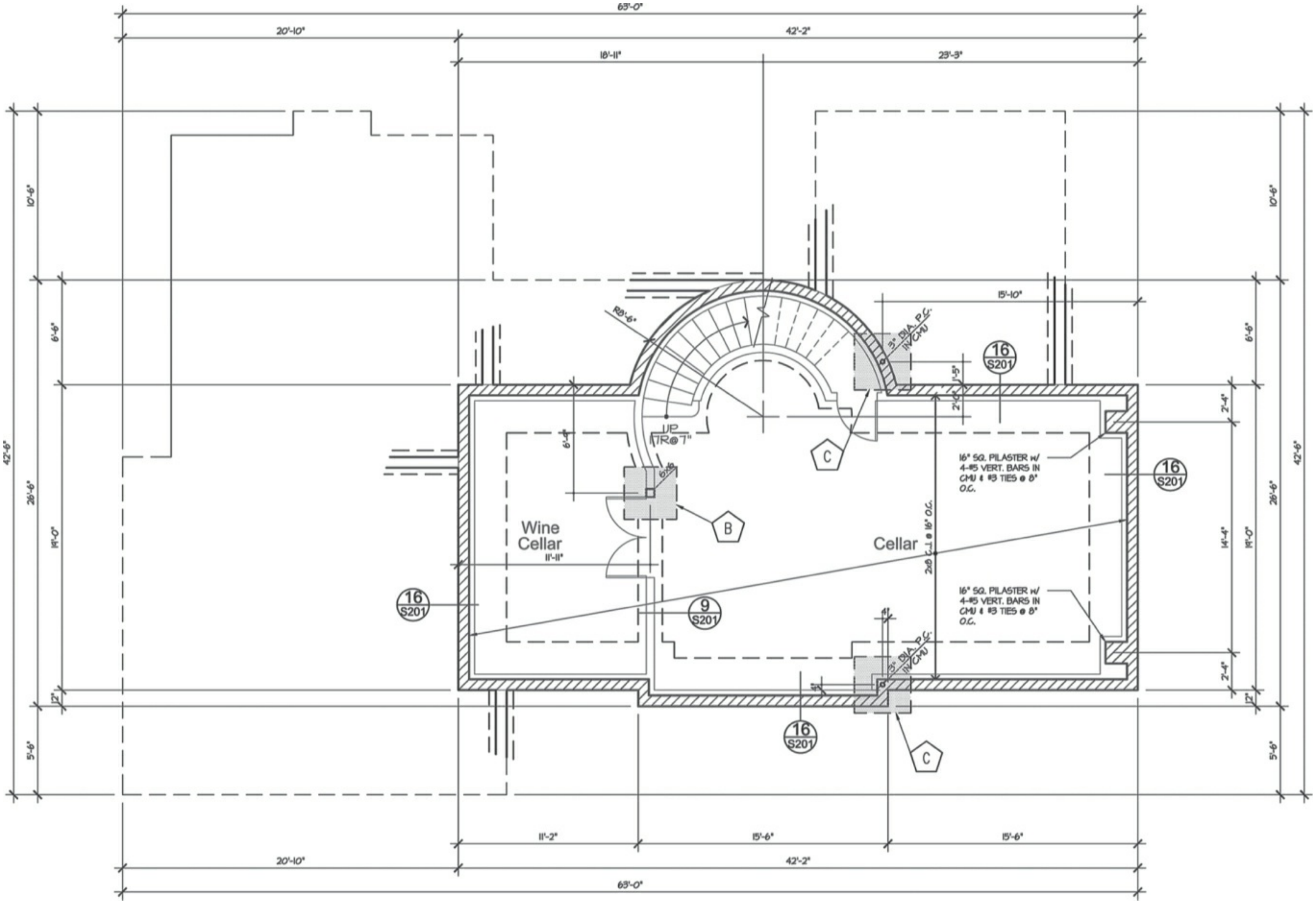


Figure 17.36 Stage IV: Foundation plan.

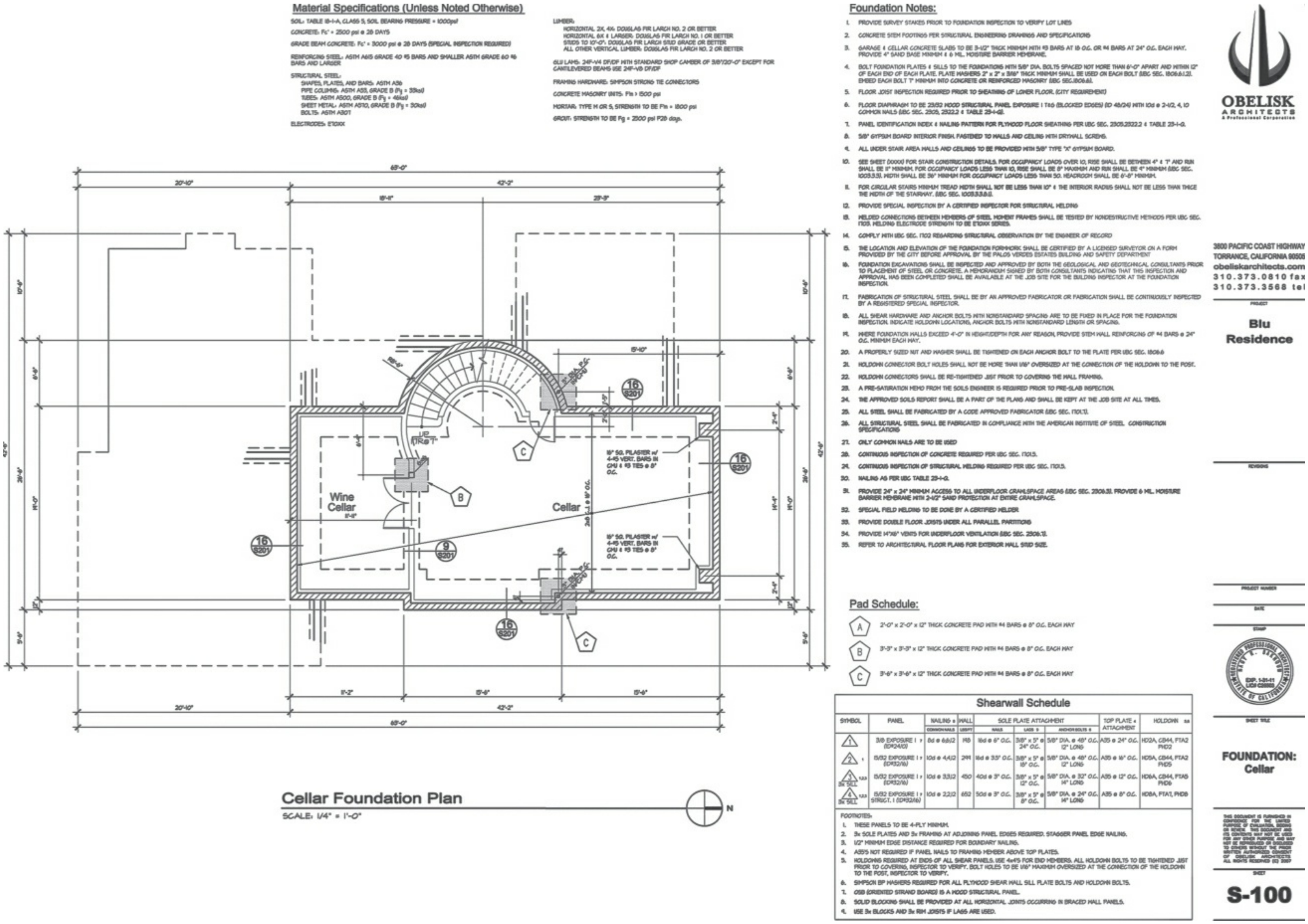
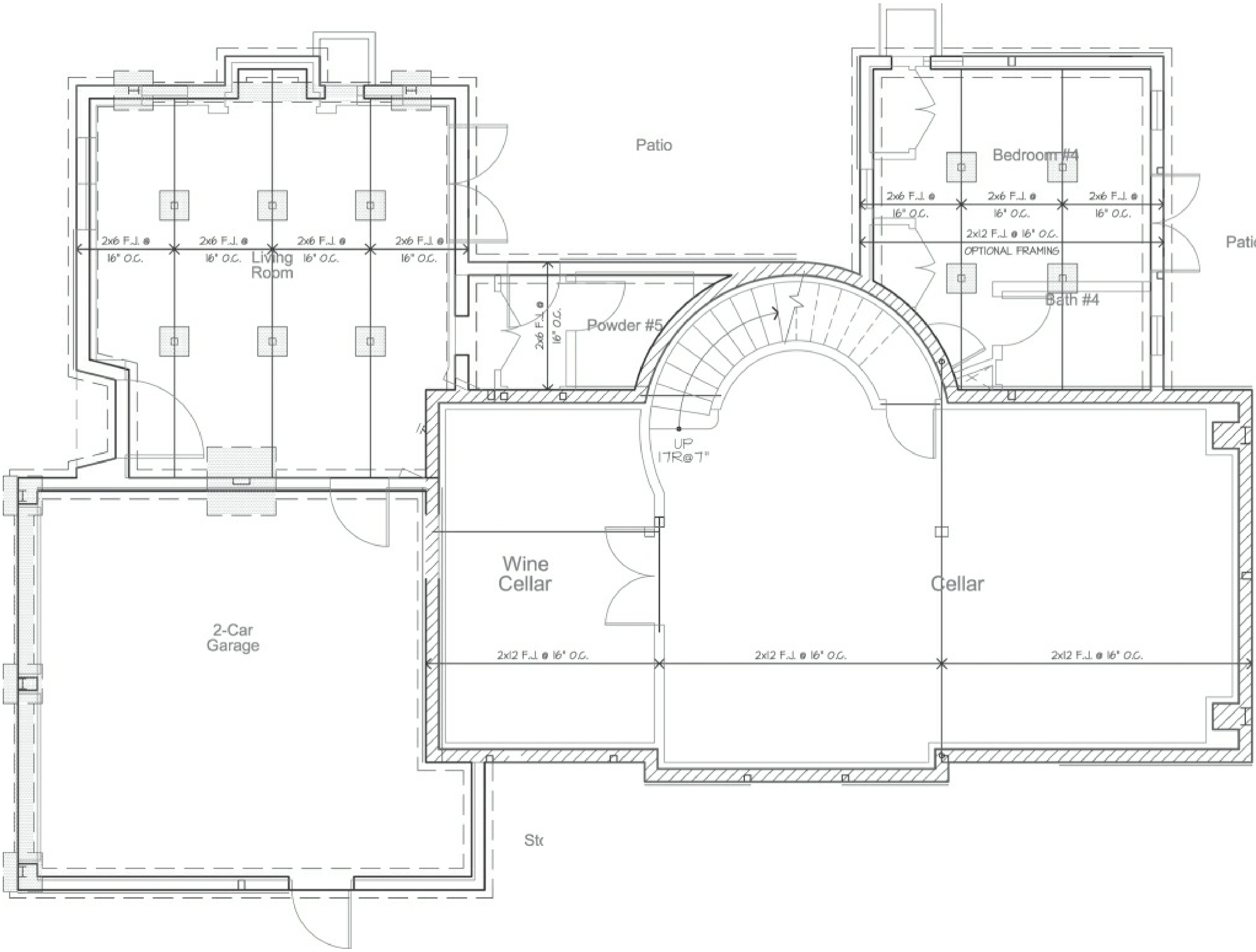


Figure 17.37 Stage IV: Foundation plan.



[Figure 17.38](#) Stage III: Foundation plan (wood).

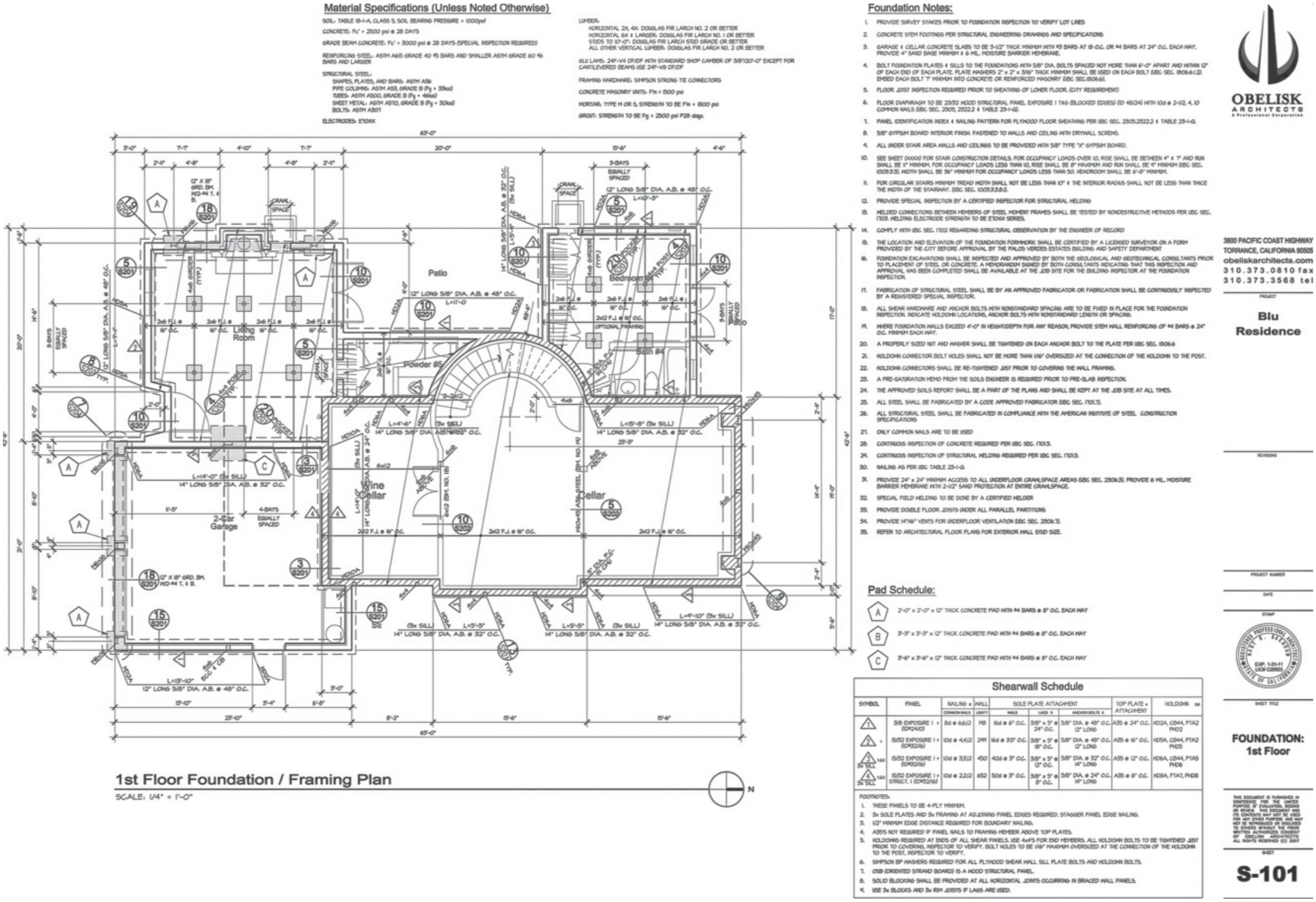


Figure 17.39 Stage V: Foundation plan.

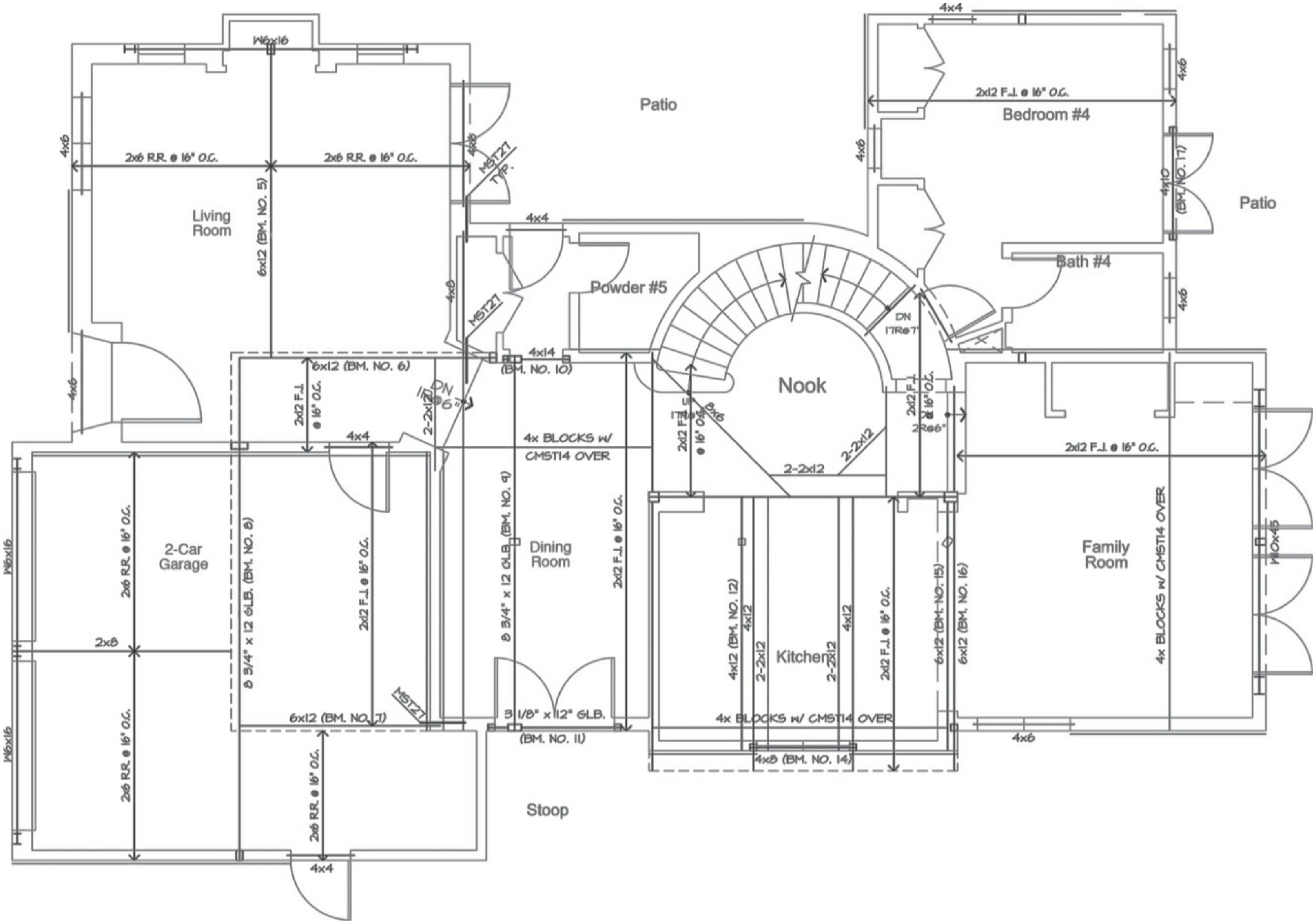


Figure 17.40 Stage I: Second…floor framing plan.

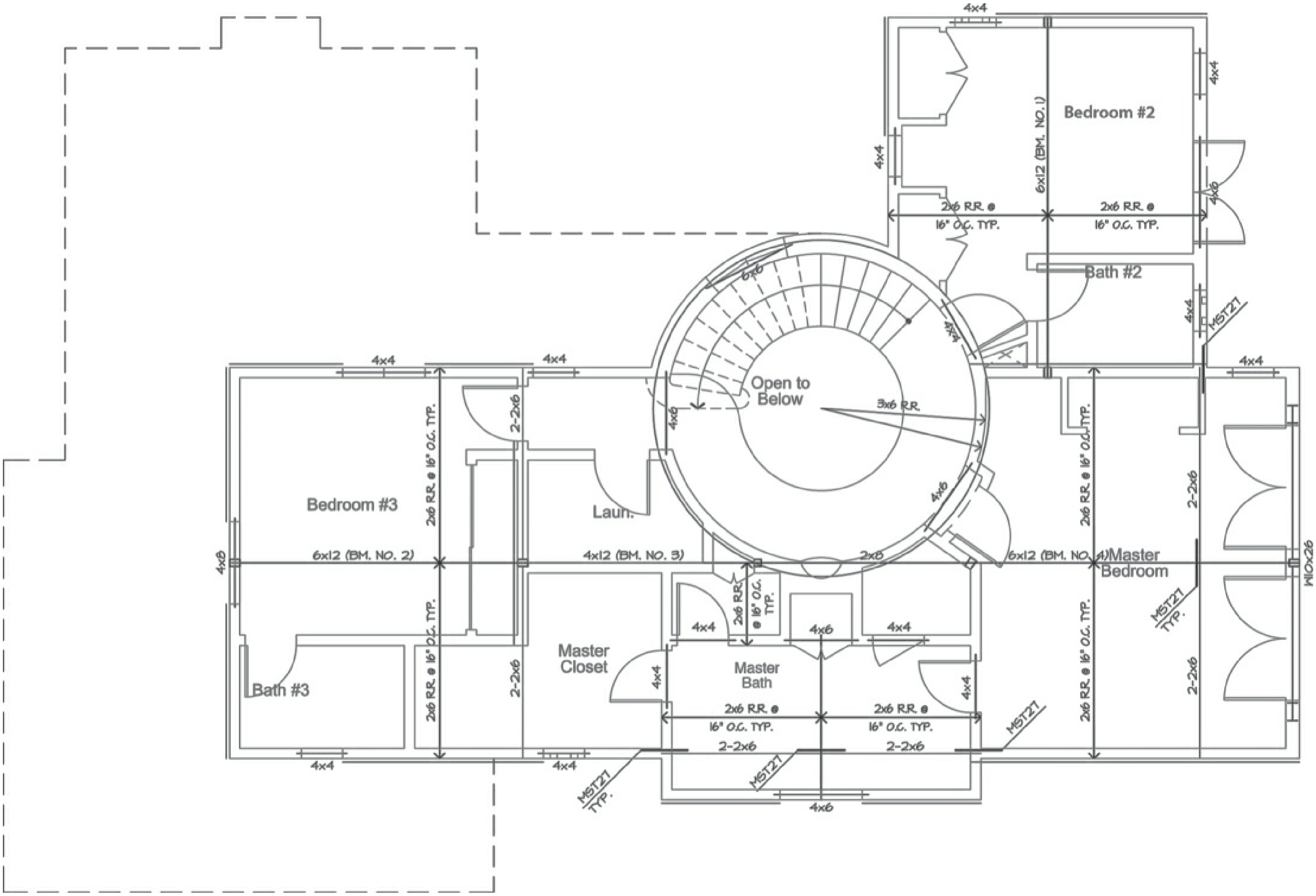


Figure 17.41 Stage I: Roof framing plan.

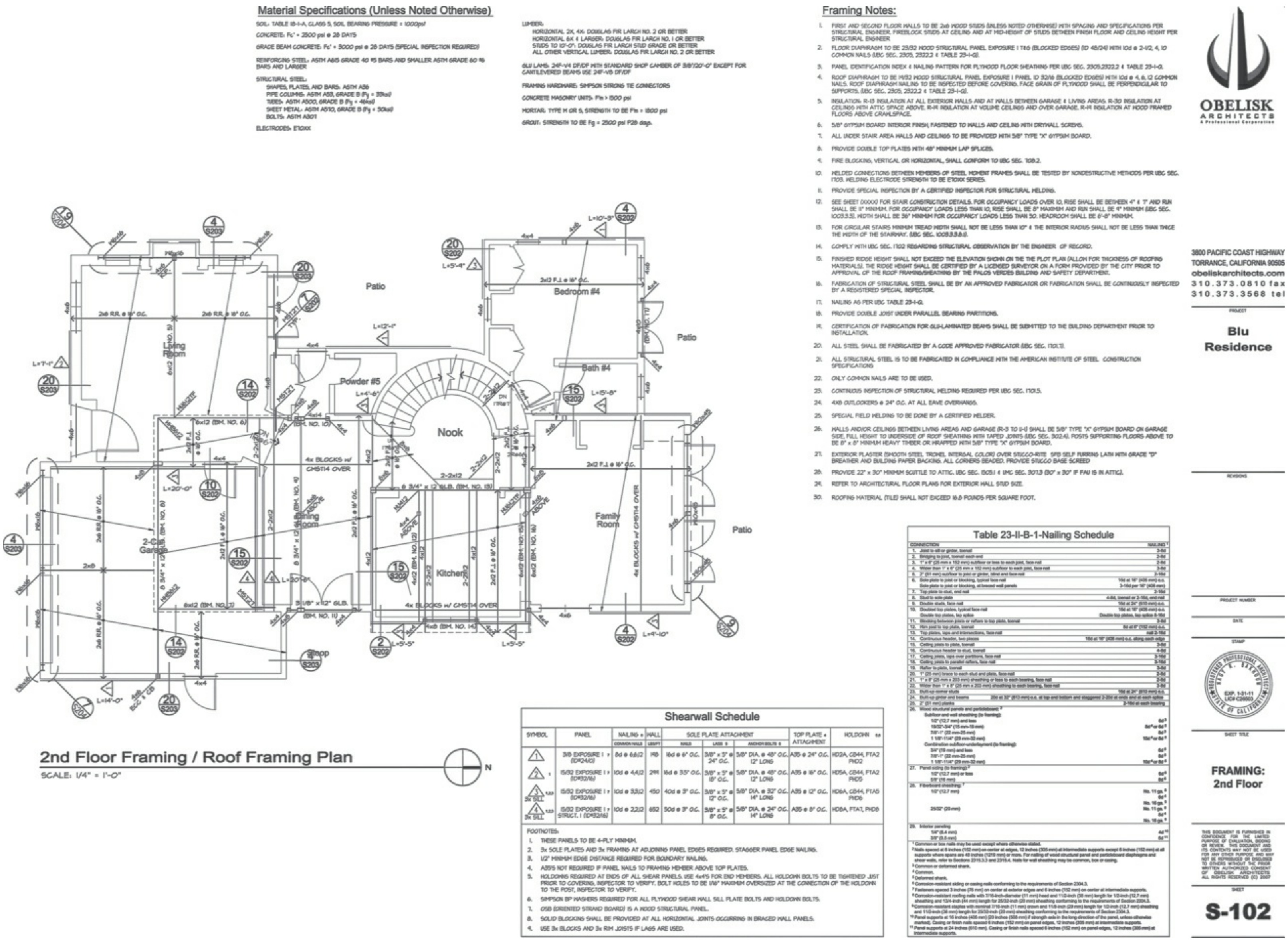


Figure 17.42 Stage II: Second‐floor framing plan.

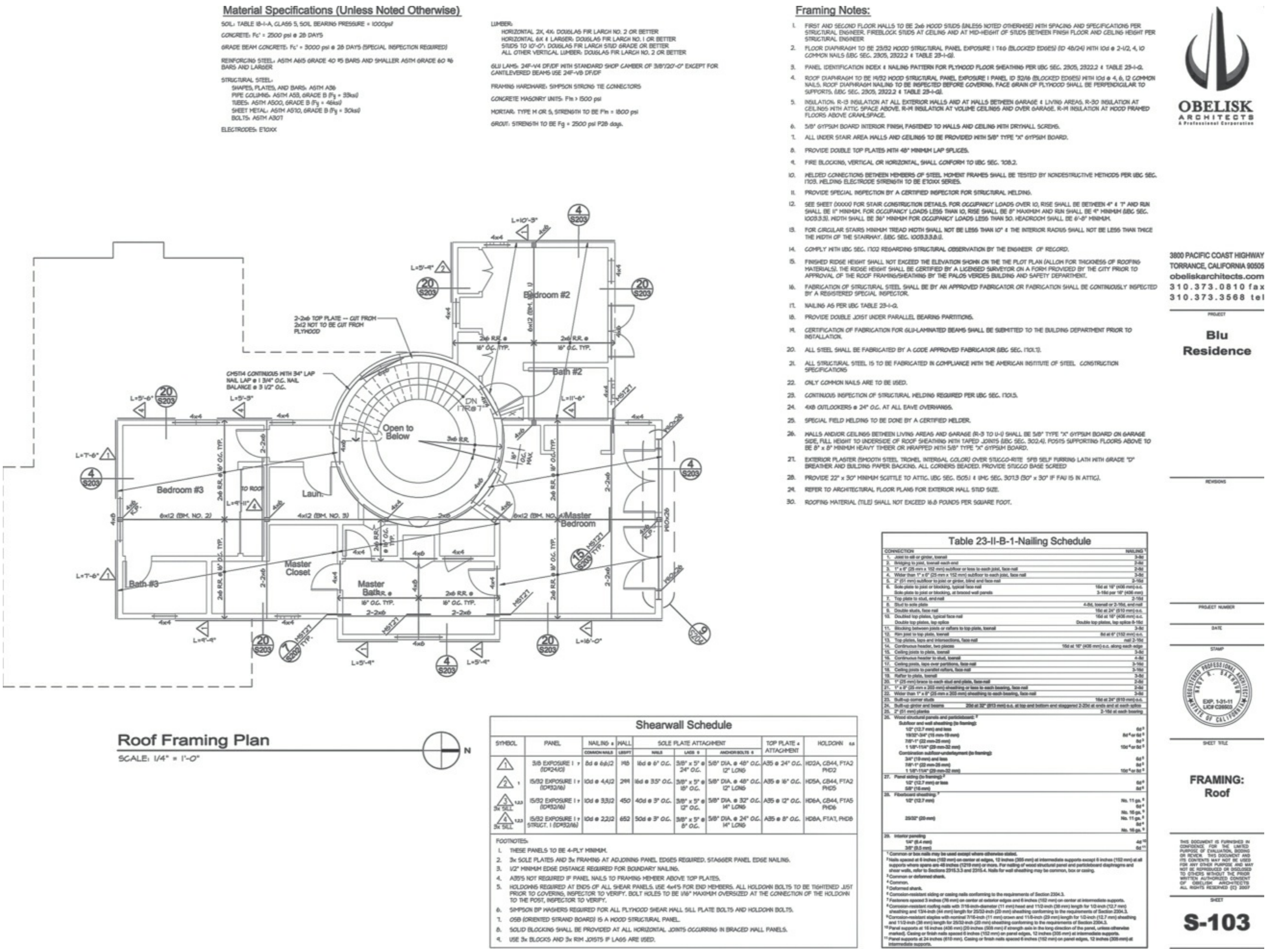


Figure 17.43 Stage II: Roof framing plan.

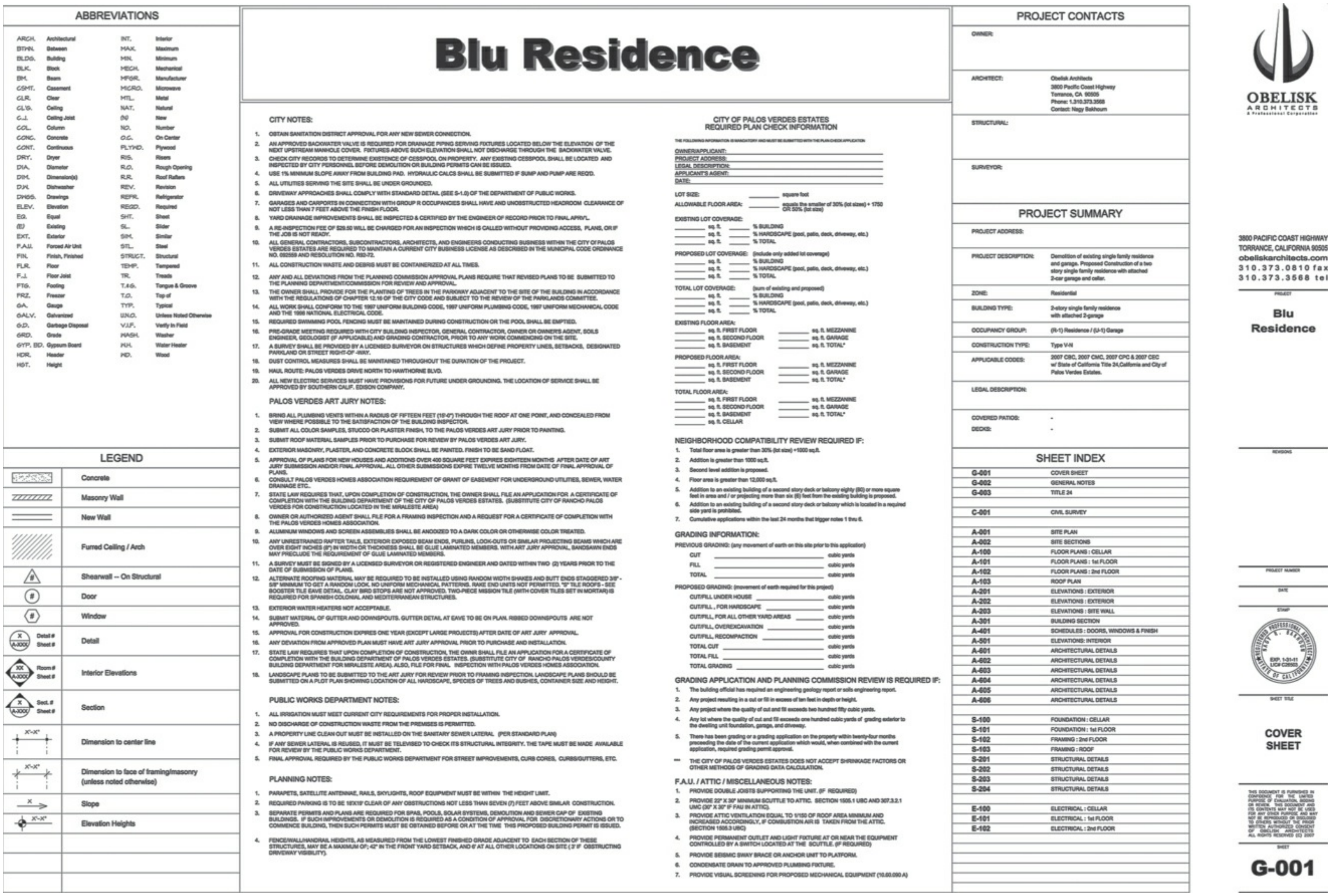


Figure 17.44 Title sheet.

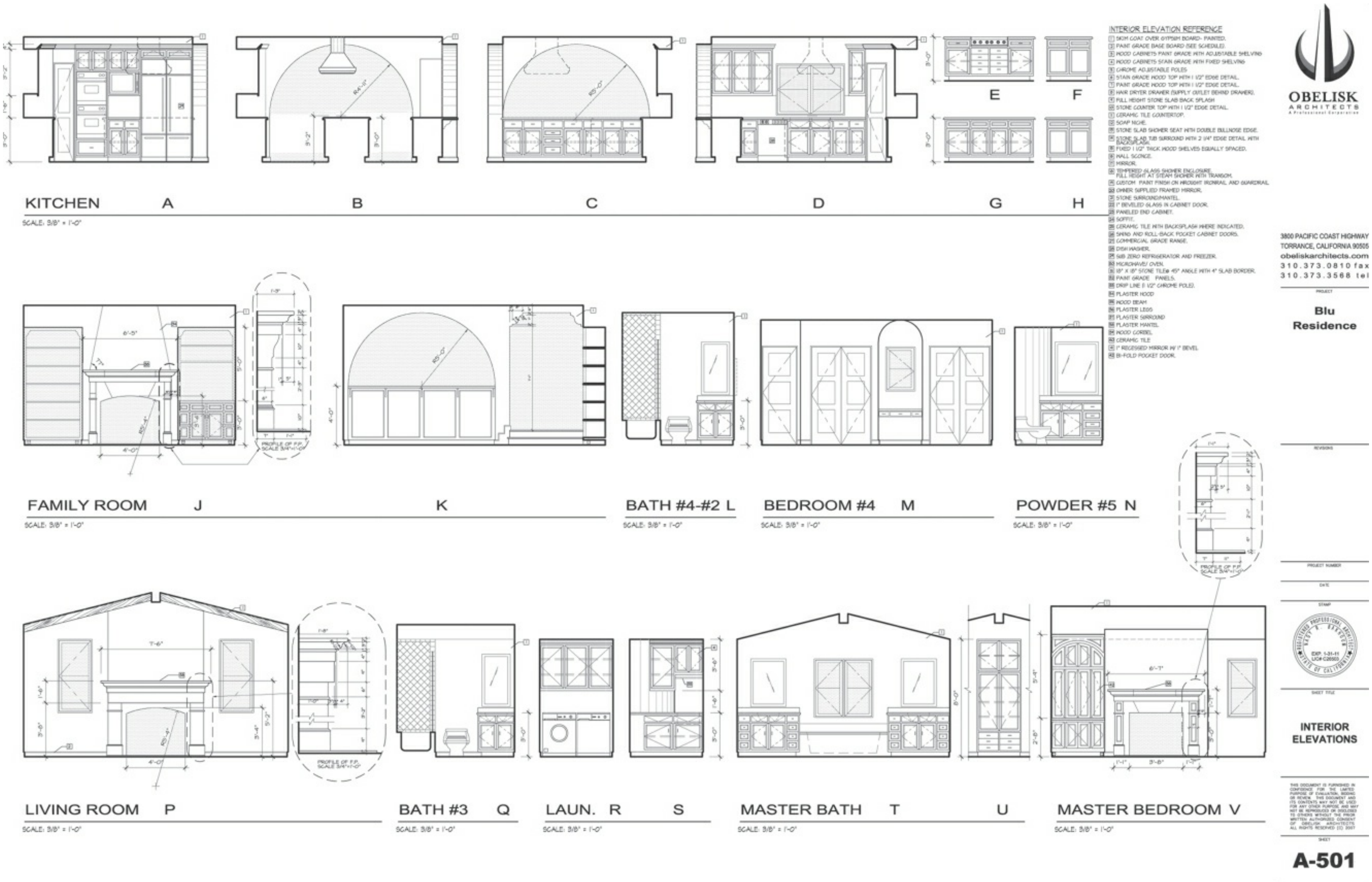


Figure 17.45 Interior elevation sheet.

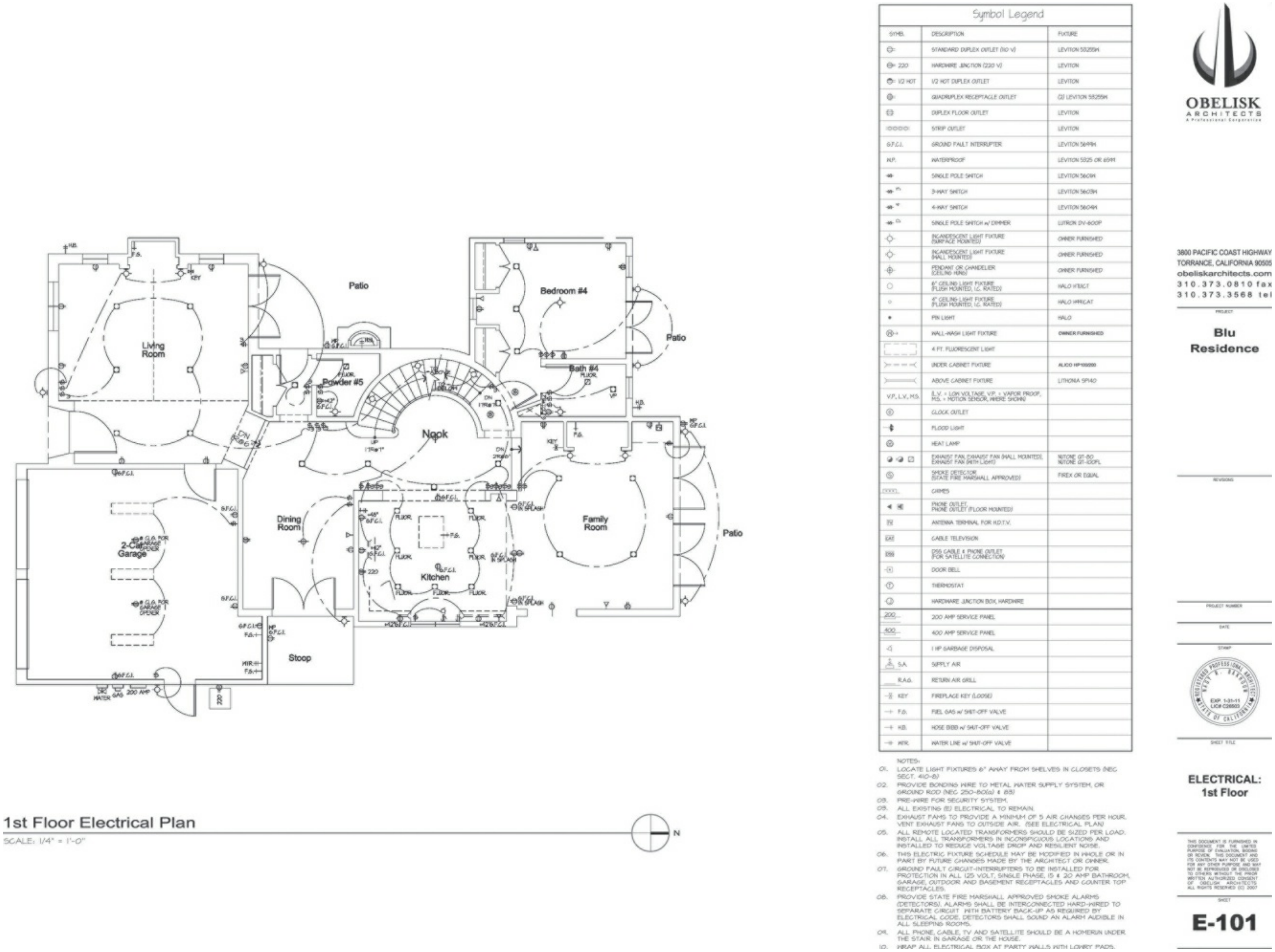


Figure 17.46 Electrical layout sheet.

BIM…DRAWN TWO…STORY WOOD…FRAMED RESIDENCE

BIM Plans

Following this text you will see a set of working drawings completed in BIM. You will note that some of the BIM conventions must be altered in order to meet the national CAD standards. BIM has come a long way in a very short time, and every edition of the program leaps ahead of the past iteration.

Here you will find a two…story single…family residence where all phases, SD, DD, CD, are all performed in BIM. See Figures 17.47 through 17.61 .

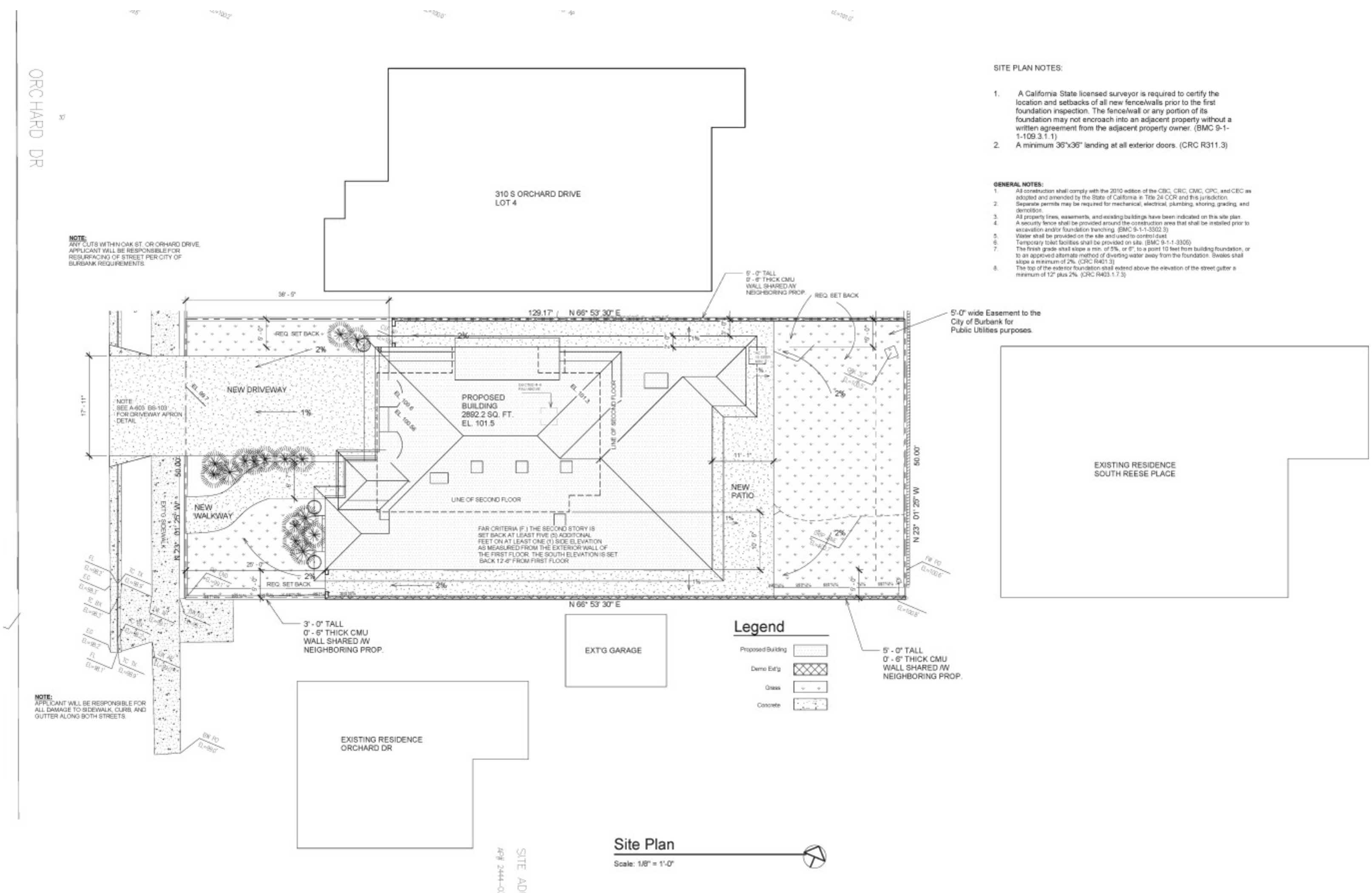


Figure 17.47 Site plan.

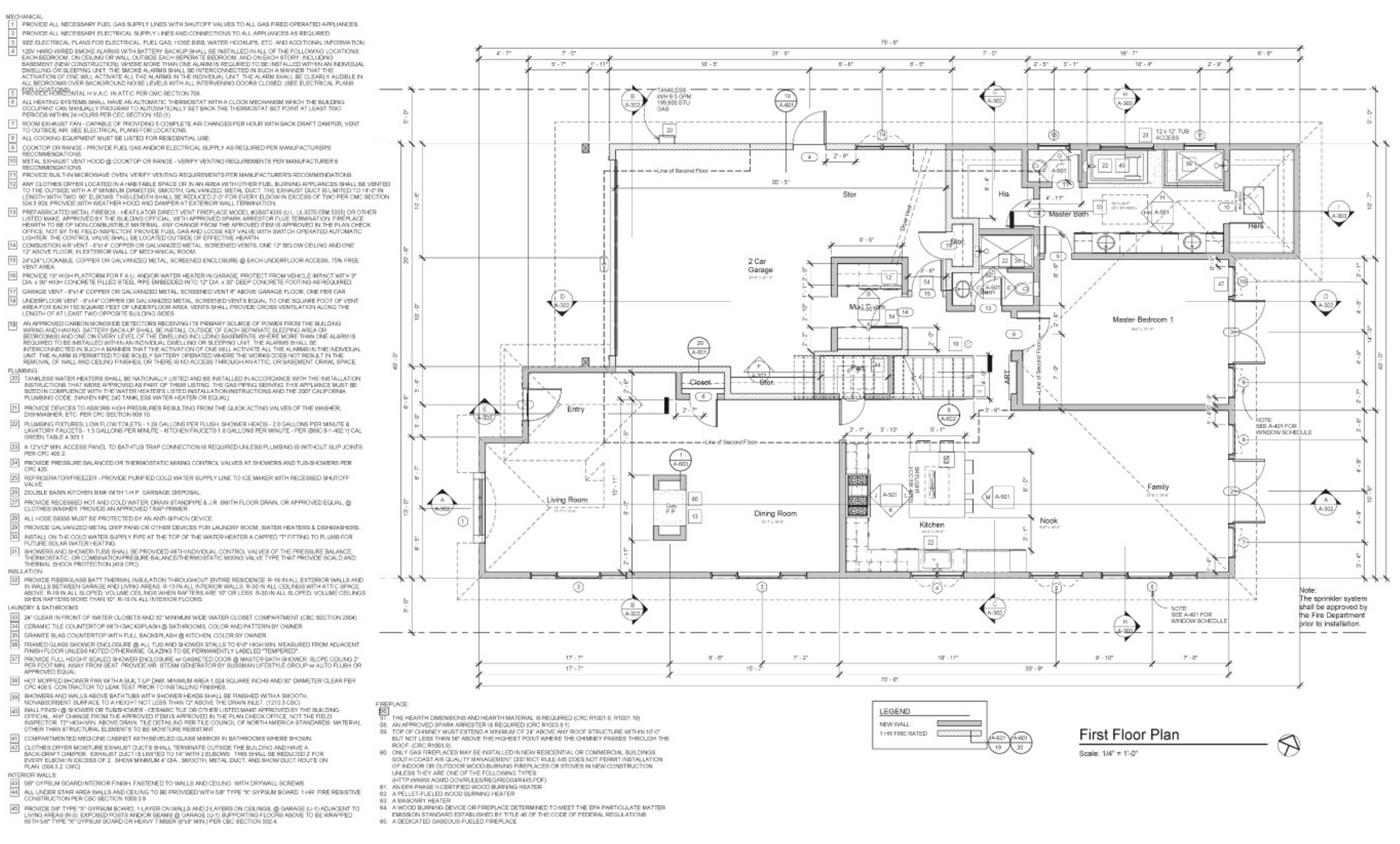


Figure 17.48 Lower…floor plan.

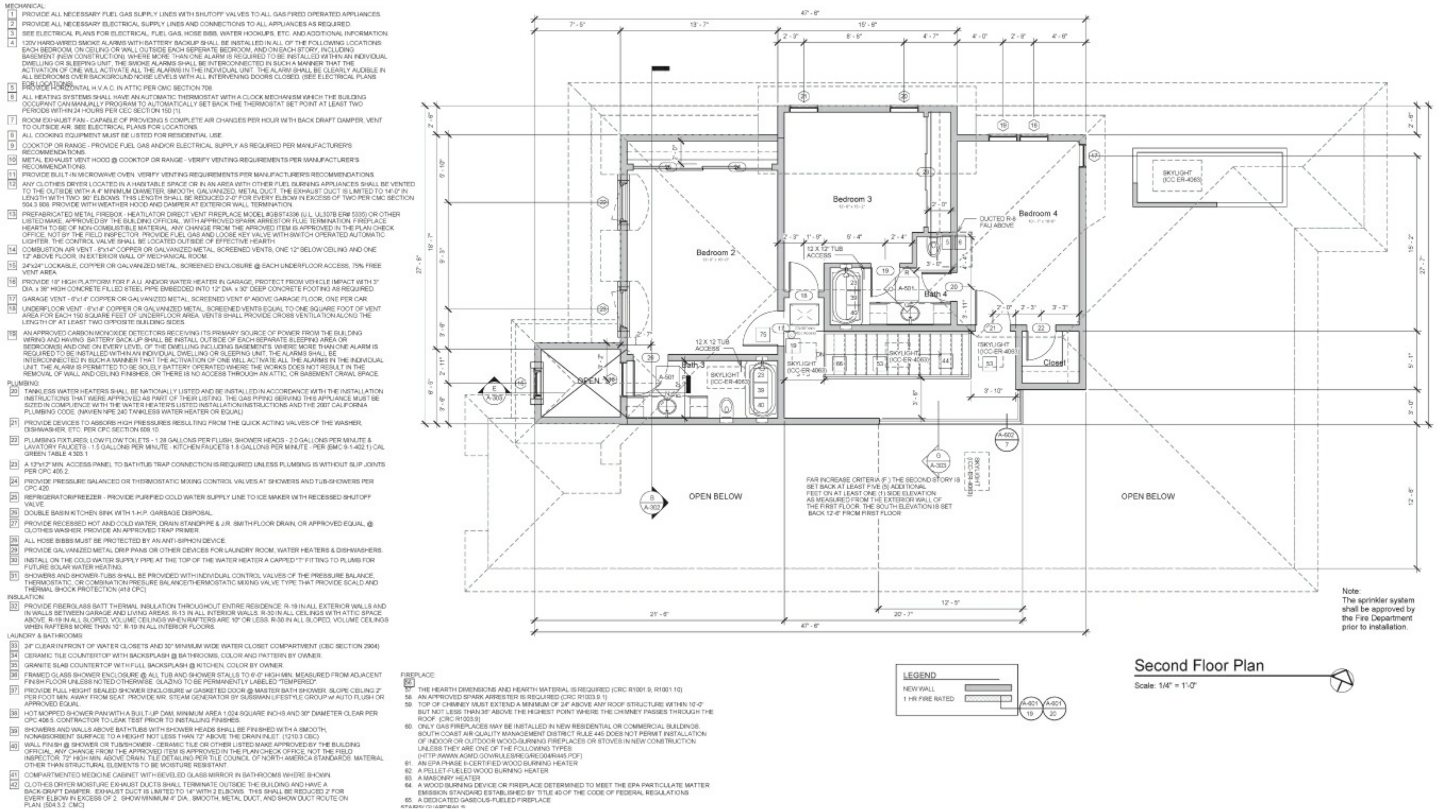


Figure 17.49 Upper…floor plan.

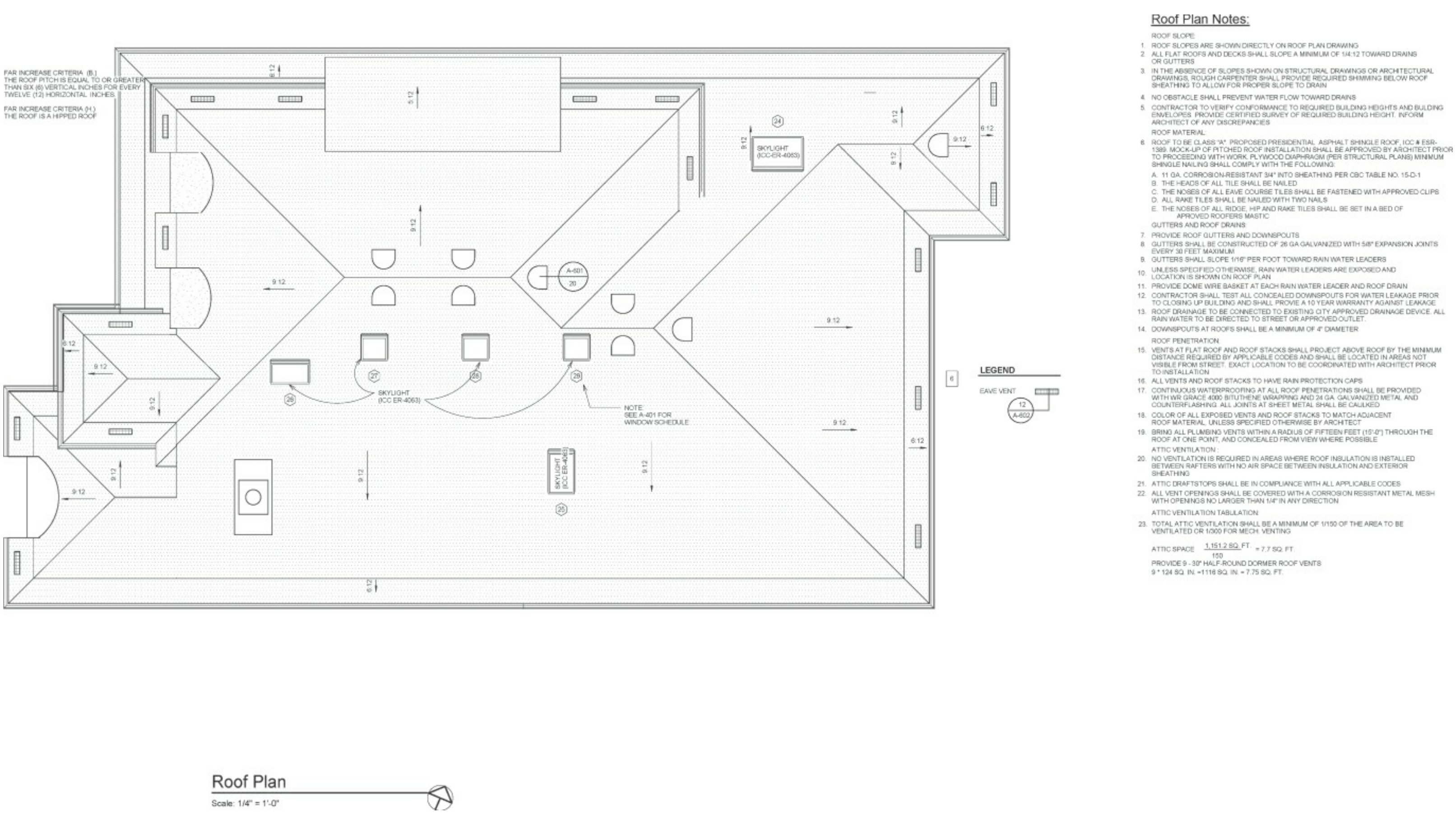


Figure 17.50 Roof plan.

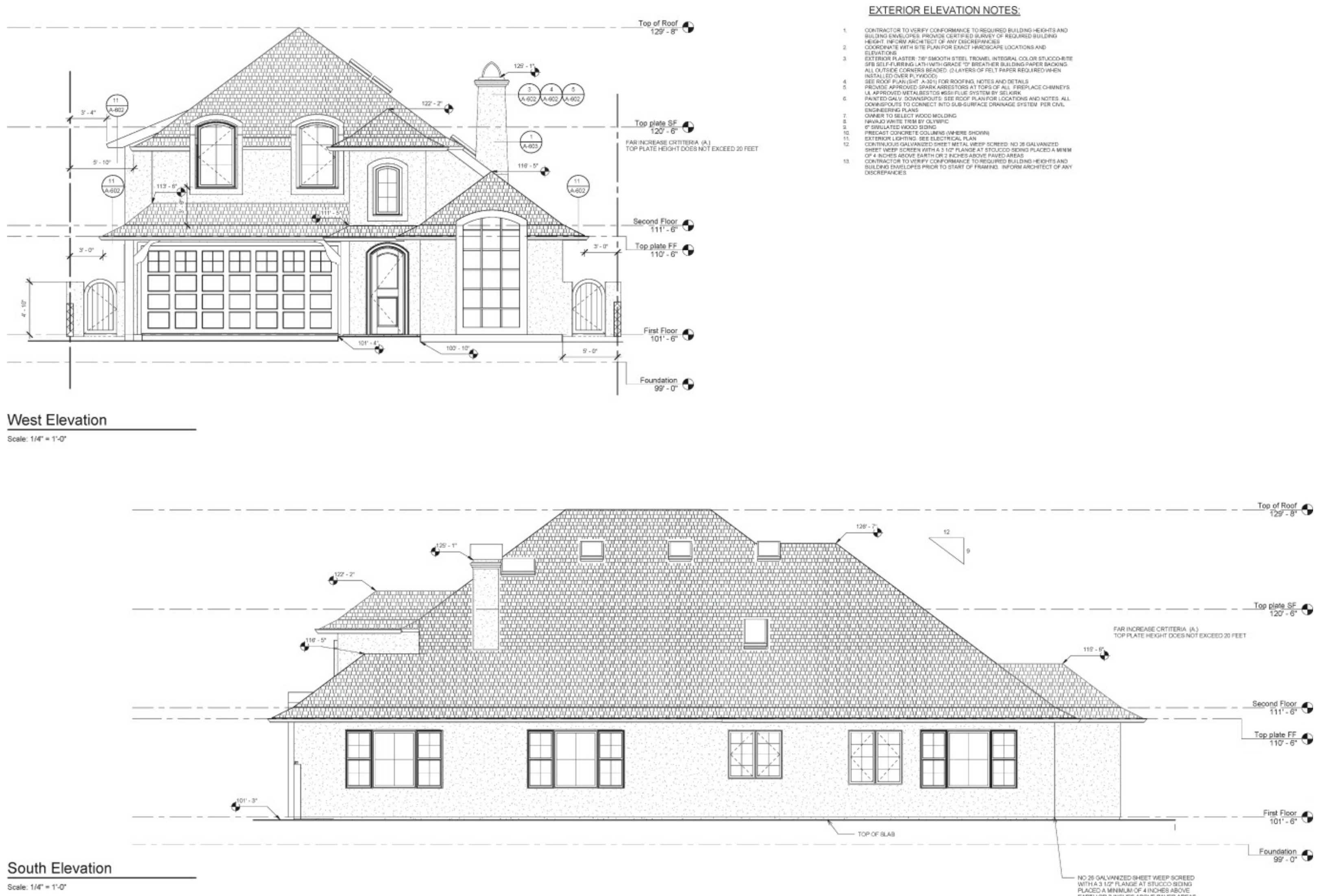


Figure 17.51 Elevations.

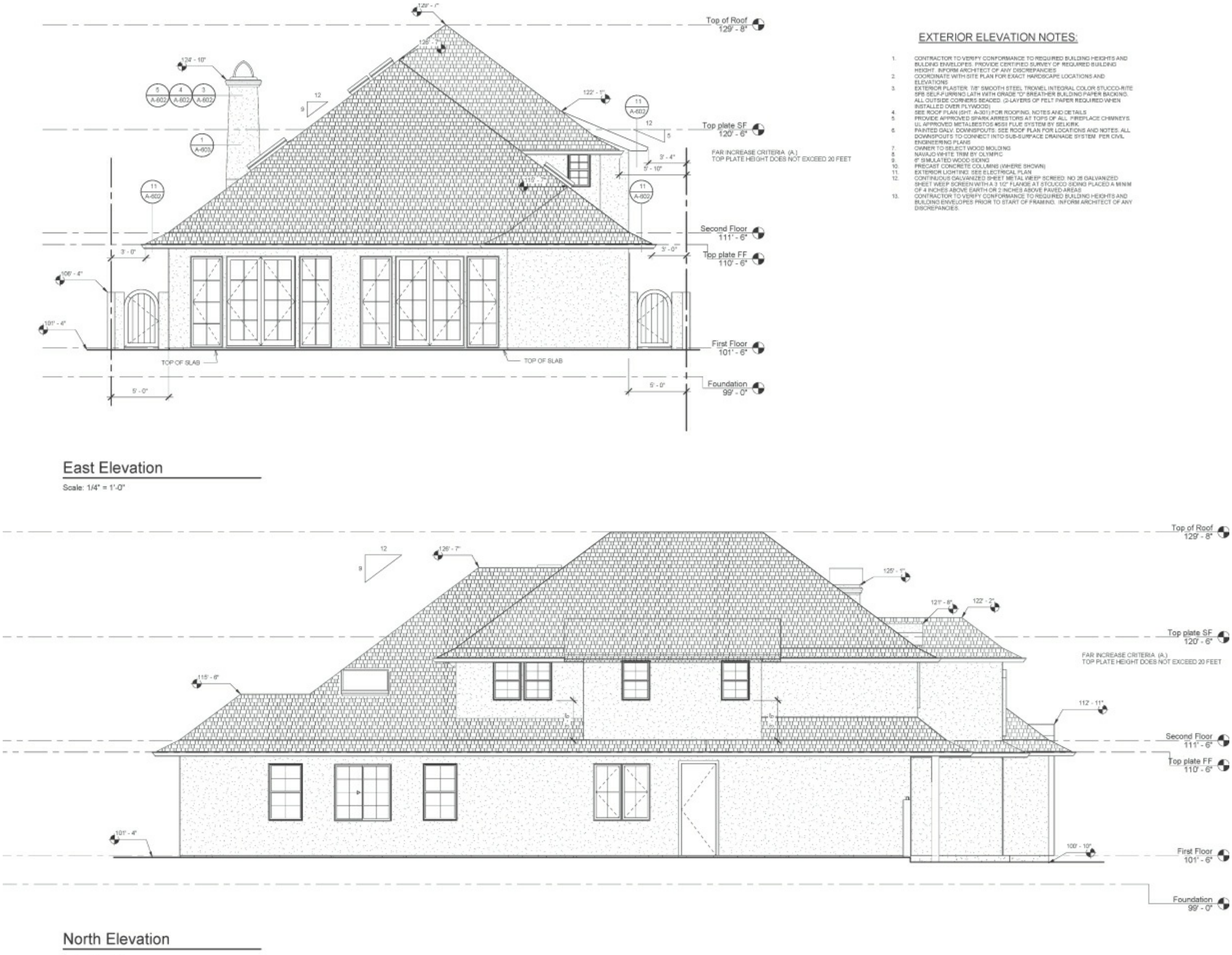


Figure 17.52 Elevation.

Figure 17.53 Sections.

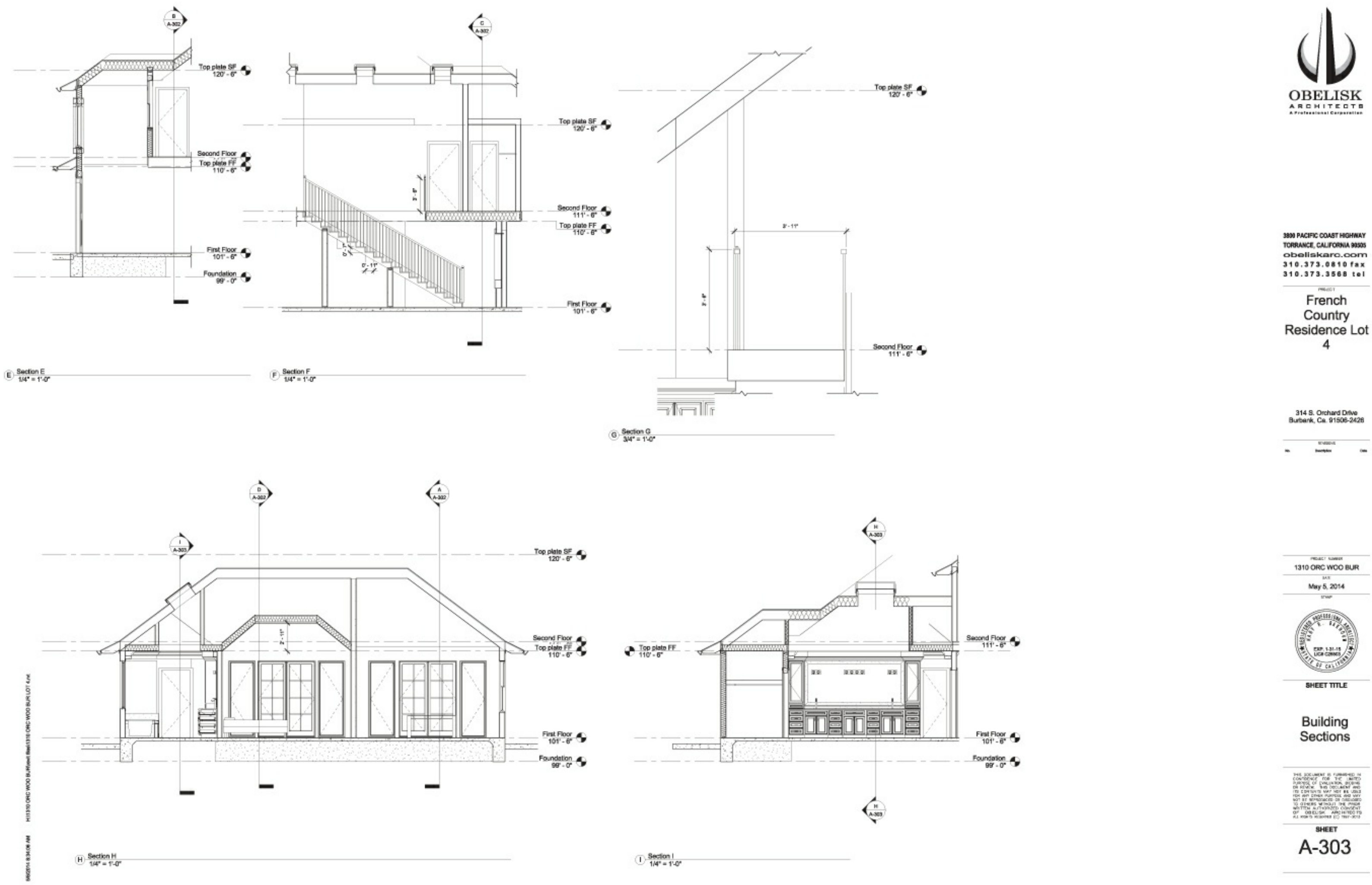
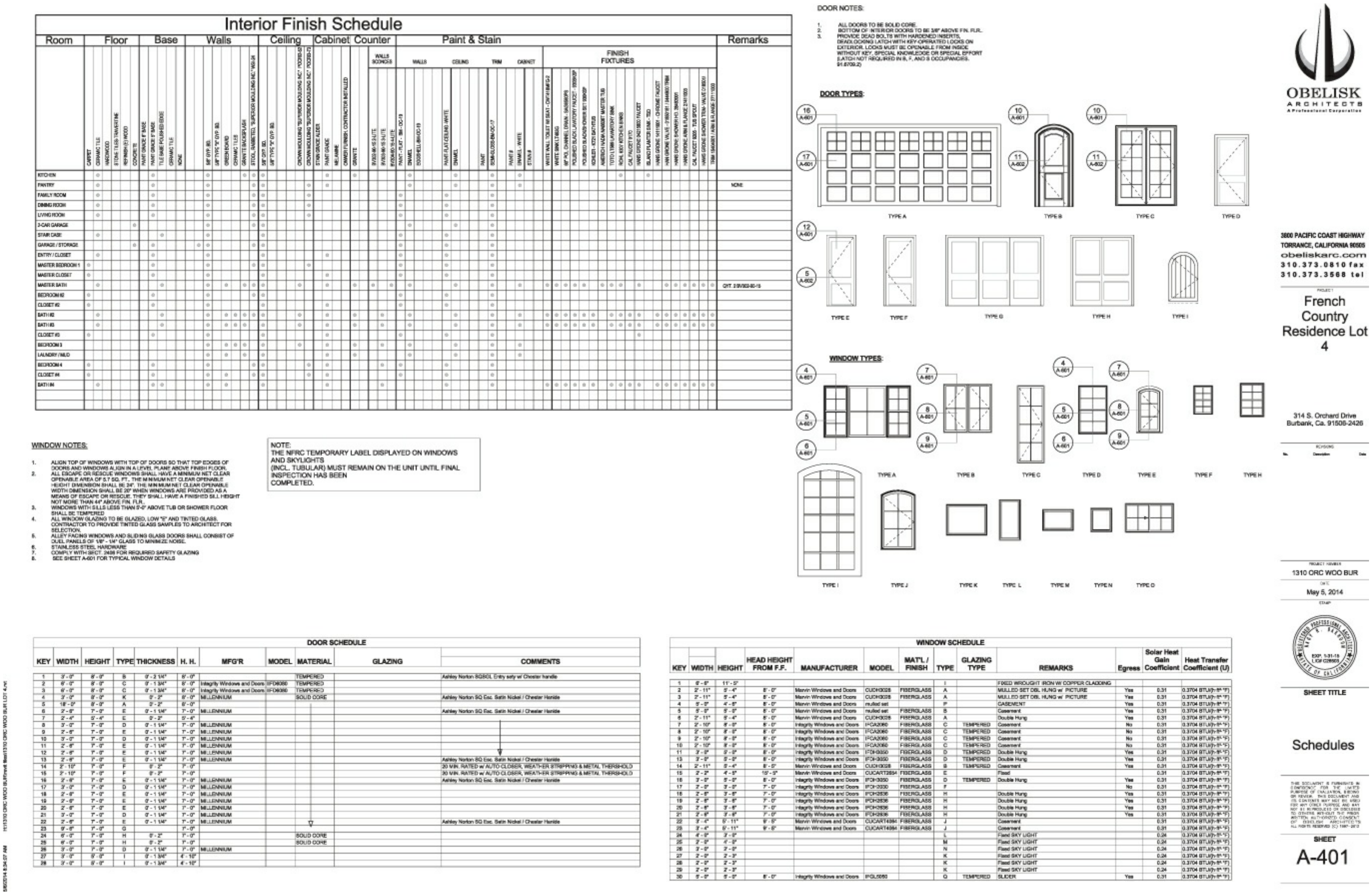


Figure 17.54 Sections.



[**Figure 17.55**](#) Schedule.

Figure 17.56 Interior elevations.

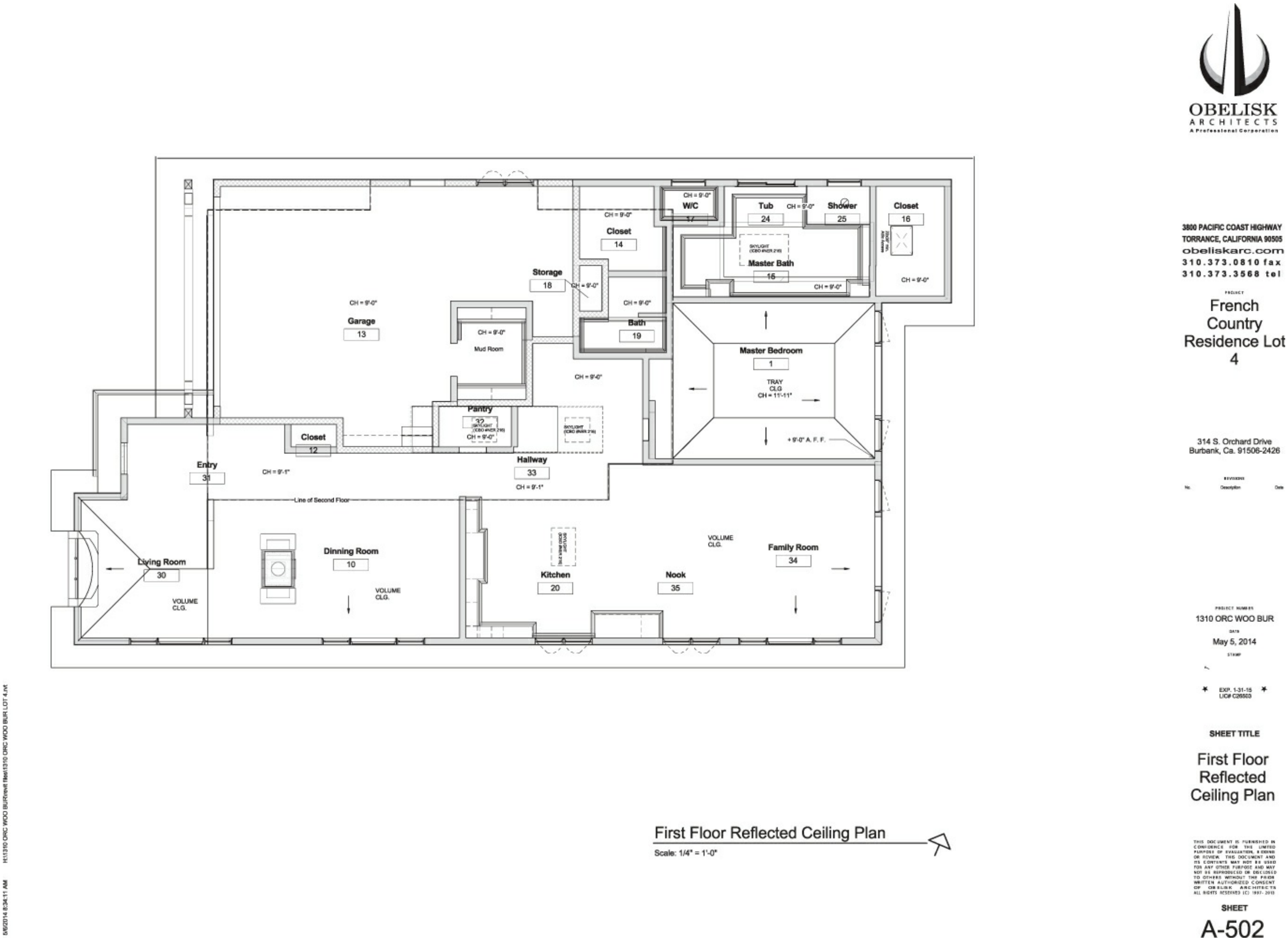
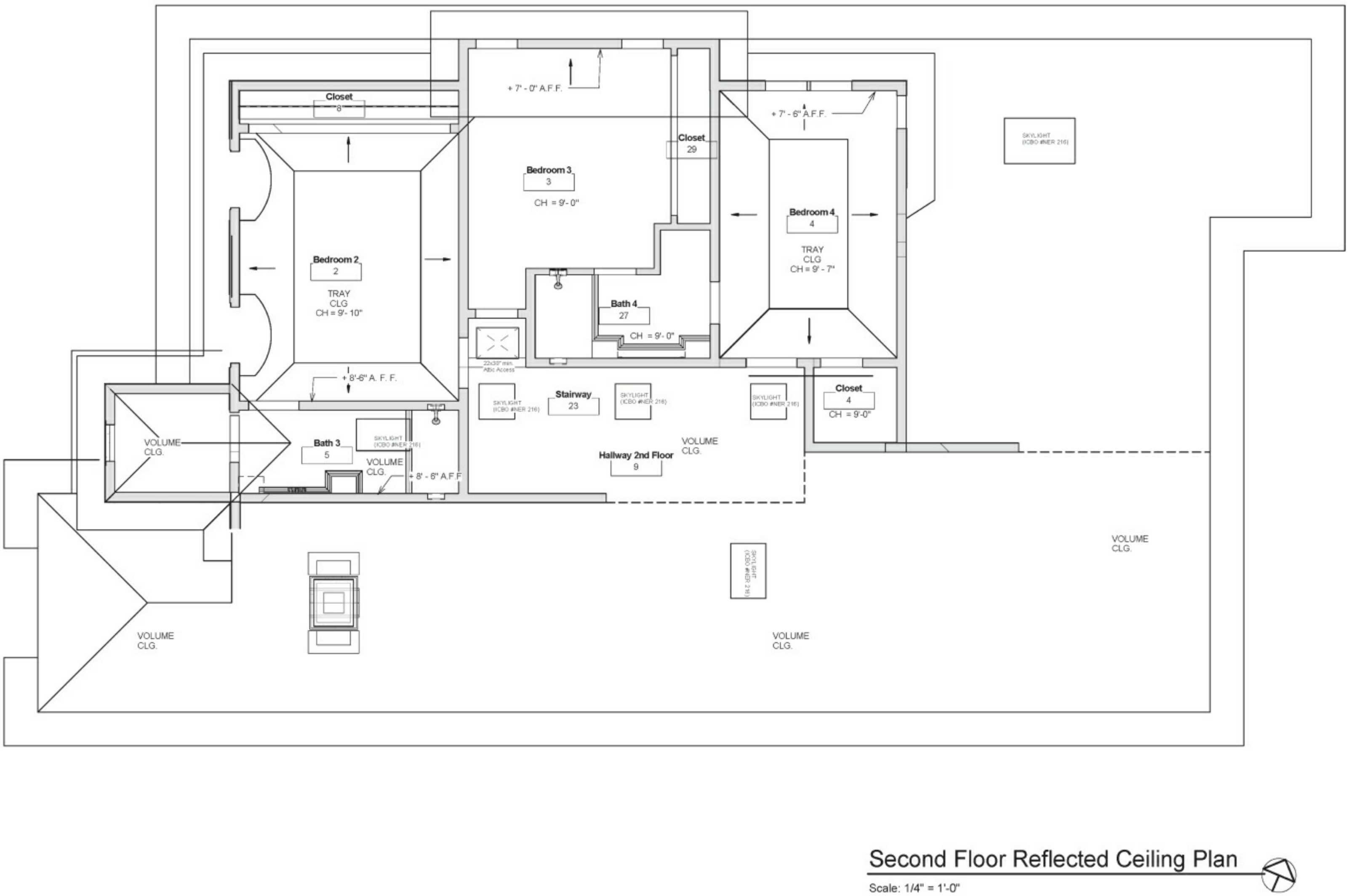


Figure 17.57 Reflected ceiling plan.



[Figure 17.58](#) Reflected ceiling plan.

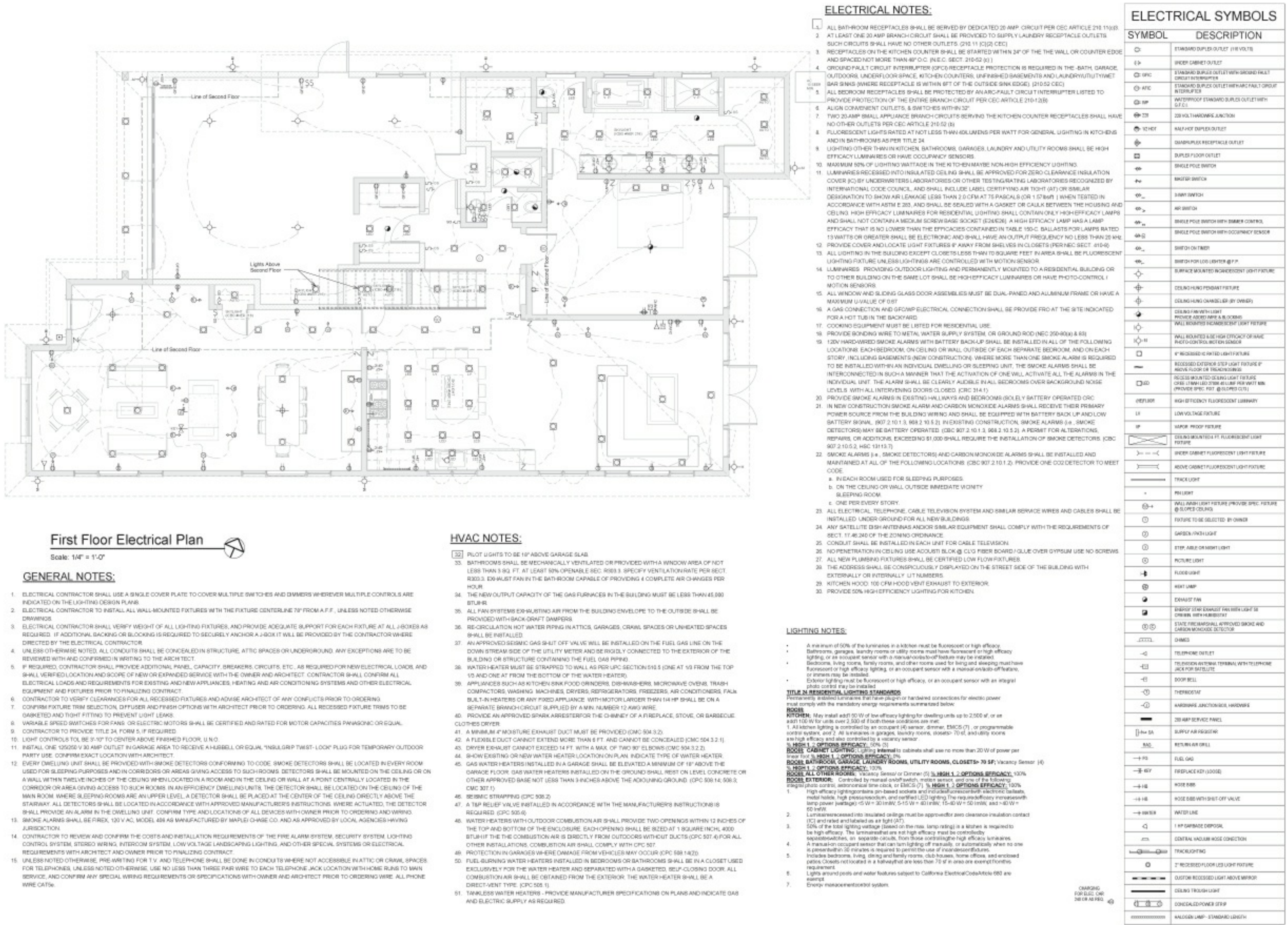


Figure 17.59 Electrical plan.

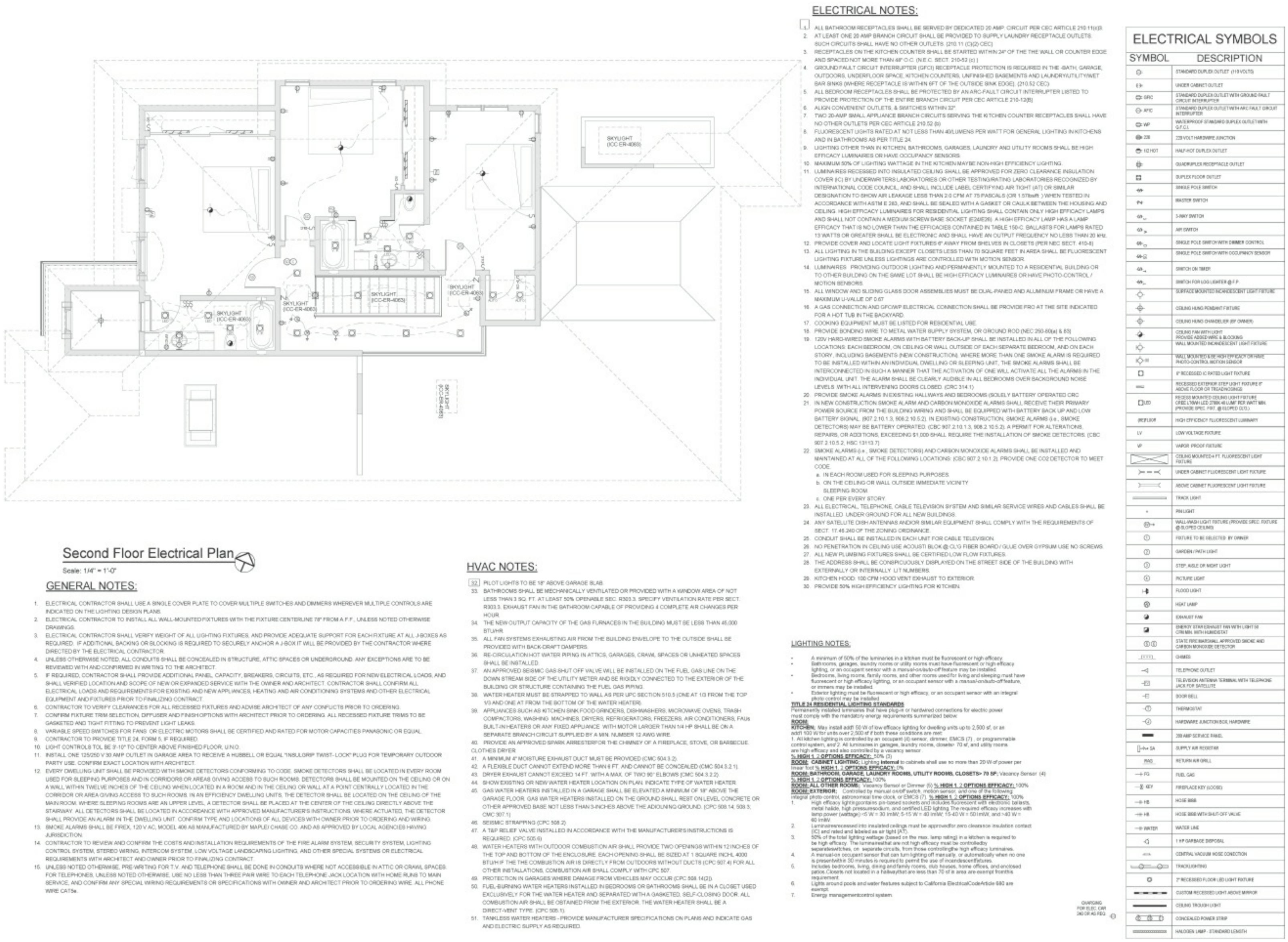


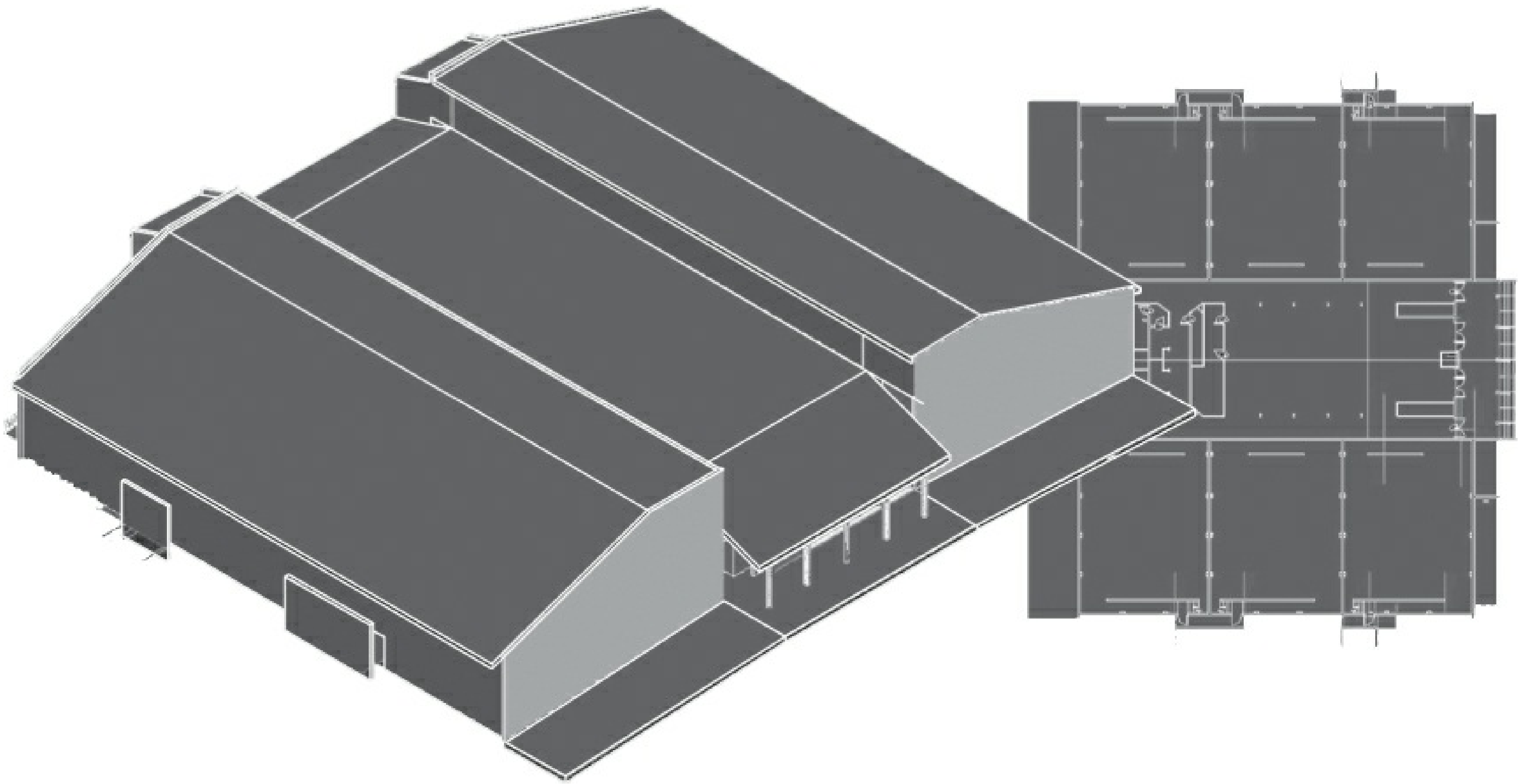
Figure 17.60 Electrical plan.

Figure 17.61 BIM rendering produced by software.

Key Term

program

Chapter 18
CLAY THEATER—STEEL/MASONRY STRUCTURE; MARGAUX—MASONRY STRUCTURE



INTRODUCTION

Before you read this chapter, review Chapters 7 through 10, where much of this information has been covered in depth. This chapter is very abbreviated and is used only to demonstrate a set of reference drawings.

The method of designing a structure varies from office to office and from school to school. Since this textbook is concerned with working drawings, we will keep it simple.

While concepts are being developed, and ideas and research materials are being considered, designs are often drawn freehand and with sketches. These preliminary sketches can also be done on computer.

CONCEPTUAL DESIGN: SITE AND CLIENT REQUIREMENTS FOR CLAY THEATER

The client required a theater building with six separate auditoriums of 200 seats each. The sloping site of approximately three acres also had stringent architectural restrictions.

The proposed structure, with six auditoriums, office, restrooms, and storage and food areas, required approximately 26,000 square feet. The seating area dictated the required

on…site parking for 400 automobiles.

To satisfy fire requirements, the primary building materials selected were structural steel and concrete block. The concrete block was chosen because it also would provide an excellent sound barrier between the auditoriums and the lobby.

The initial concept provided for three auditoriums on each side of a central service core, which would contain the lobby, toilet facilities, food bar, and storage areas. The core would provide controlled circulation and access to the auditoriums, facilities, and required fire exits. Efficient arrangements for the 200 seats and fire code requirements governed the auditorium dimensions. The wall dimensions also had to be compatible with the concrete…block module. The upper…floor level would contain the projection rooms, the manager's office, an employee toilet, and additional storage rooms. The stair location for this upper area was also governed by fire department and building code design criteria.

DESIGN DEVELOPMENT PUNCH LIST

The punch list for this theater project was based on the site plan and the client requirements. It included notes on all sorts of matters, as well as design possibilities, ideas, and reminders:

- Walk the site with the client.
- Egress and ingress available only from the west.
- Best location on the site for parking on the south side.
- Two traffic lanes at 90°.
- Explore desirable areas for lobbies, exit stairs, utilities, and trash areas.
- Establish locations of supporting steel columns.
- Locate disability parking per ADA requirements.
- Locate ice bank cooling system.
- Second…floor load versus required stairs, restrooms, and potential location for mechanical ducts.
- Add third floor and revise square footage.
- Verify exact position of steel columns in relationship to third floor.
- Include stairs for roof access.
- Explore different types of windows and finishes.
- Consult structural engineers early for:
    - Circular opening
    - Shear walls to relieve starkness of solid walls

- Continuing curvilinear walls
- Shape and mass of the sculptured concrete element around columns

- Explore and decide on exterior surface materials for curvilinear walls.

INITIAL SCHEMATIC STUDIES

After programming the basic physical requirements for this proposed project, we began schematic site development.

Stage I

The irregularly shaped site had a west…to…east crossfall averaging 22′ from the lowest to the highest grade. See Figure 18.1. Complicating the site further was a 25′…wide utility easement located near the center of the site. We could not build any of the structure in this easement.

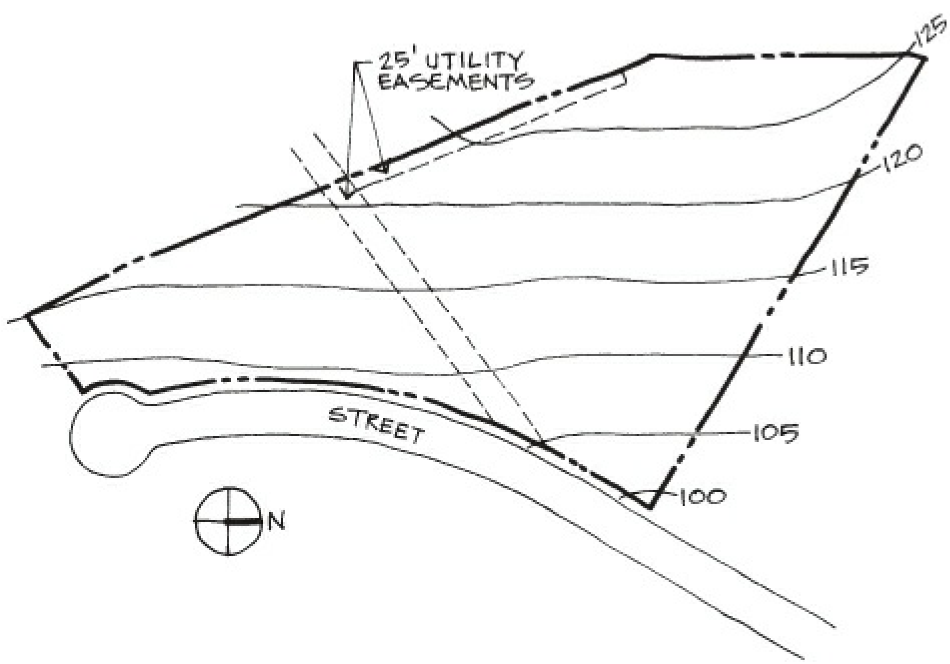


Figure 18.1 Clay Theater—preliminary site plan.

Stage II

The initial schematic site study, shown in Figure 18.2, depicts the structure located north of the utility easement on the upper portion of the site. We thought this location would provide the most suitable parking layout for access to the theater, as well as a higher floor elevation for site drainage. The site entrance for automobiles is from the east property line only.

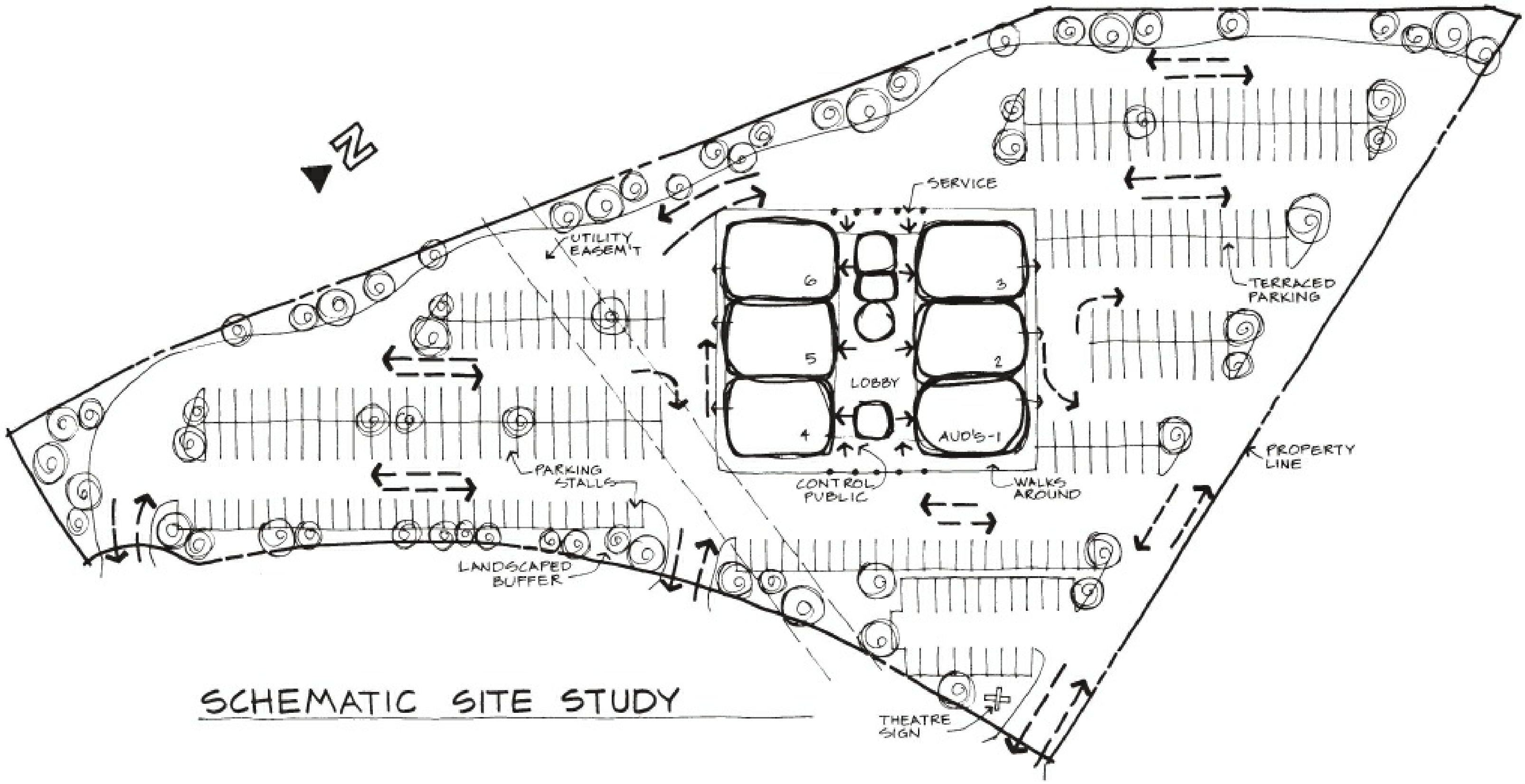


Figure 18.2 Clay Theater—schematic site study.

Stage III

After the schematic site development was completed, we designed the scaled preliminary first…floor plan (Figure 18.3) and preliminary parking layouts. Client requirements determined the first…level floor plan. Parking layouts and automobile circulation were designed to be compatible with the natural topography of the site; we paralleled the parking stalls and driveways with the existing grades. We also terraced the parking levels. This reduced the amount of rough and finish grading to be done. Stairs, as well as ramps for disabled persons, were provided at the front of the theater.

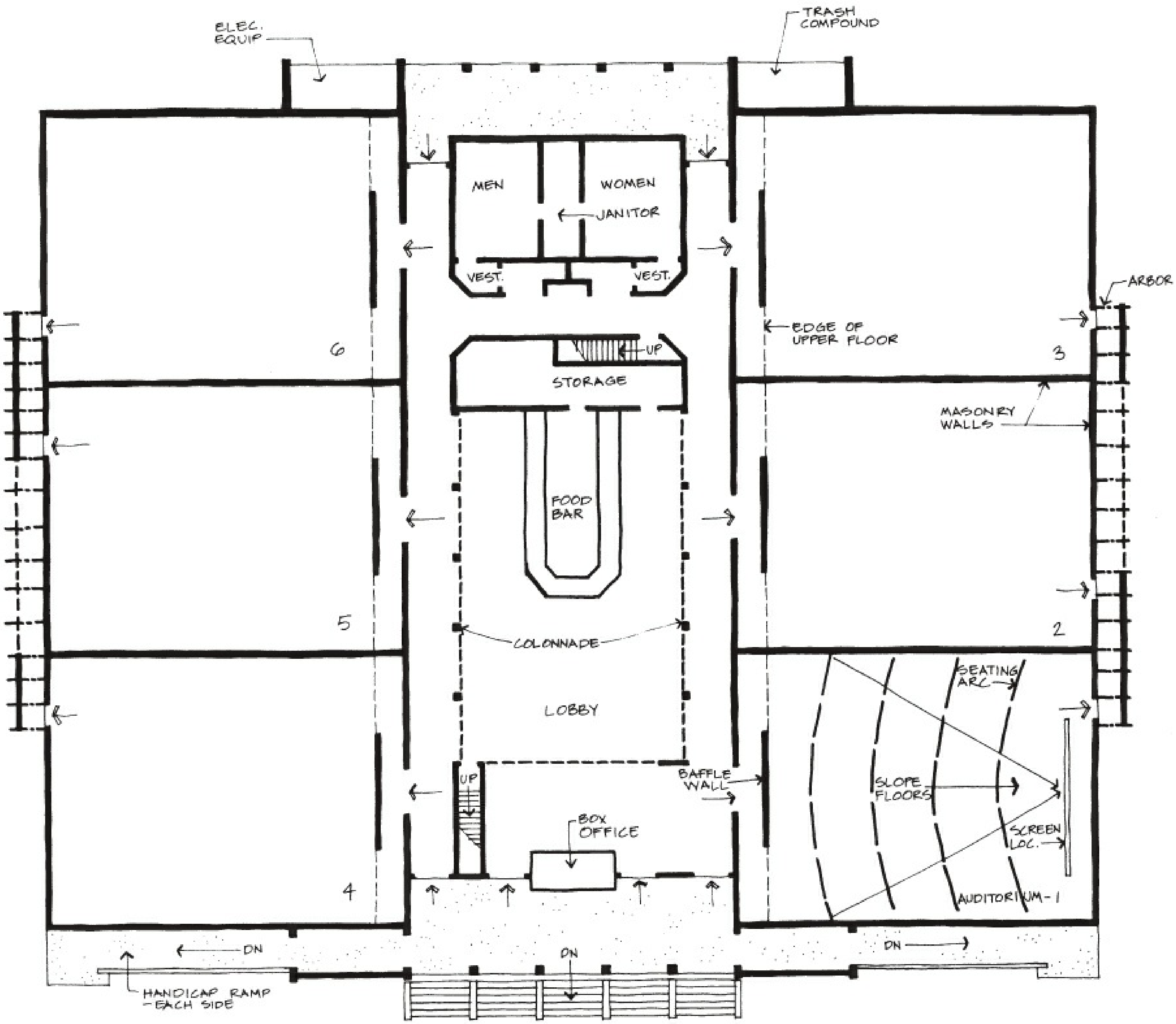


Figure 18.3 Clay Theater—preliminary ground…floor plan.

Stage IV

From the scaled preliminary first…floor plan, we made overlay studies of the second floor. Correct projector port locations for each auditorium, and required exit locations, determined the second…floor design. Other spaces and their locations were more flexible. See Figure 18.4.

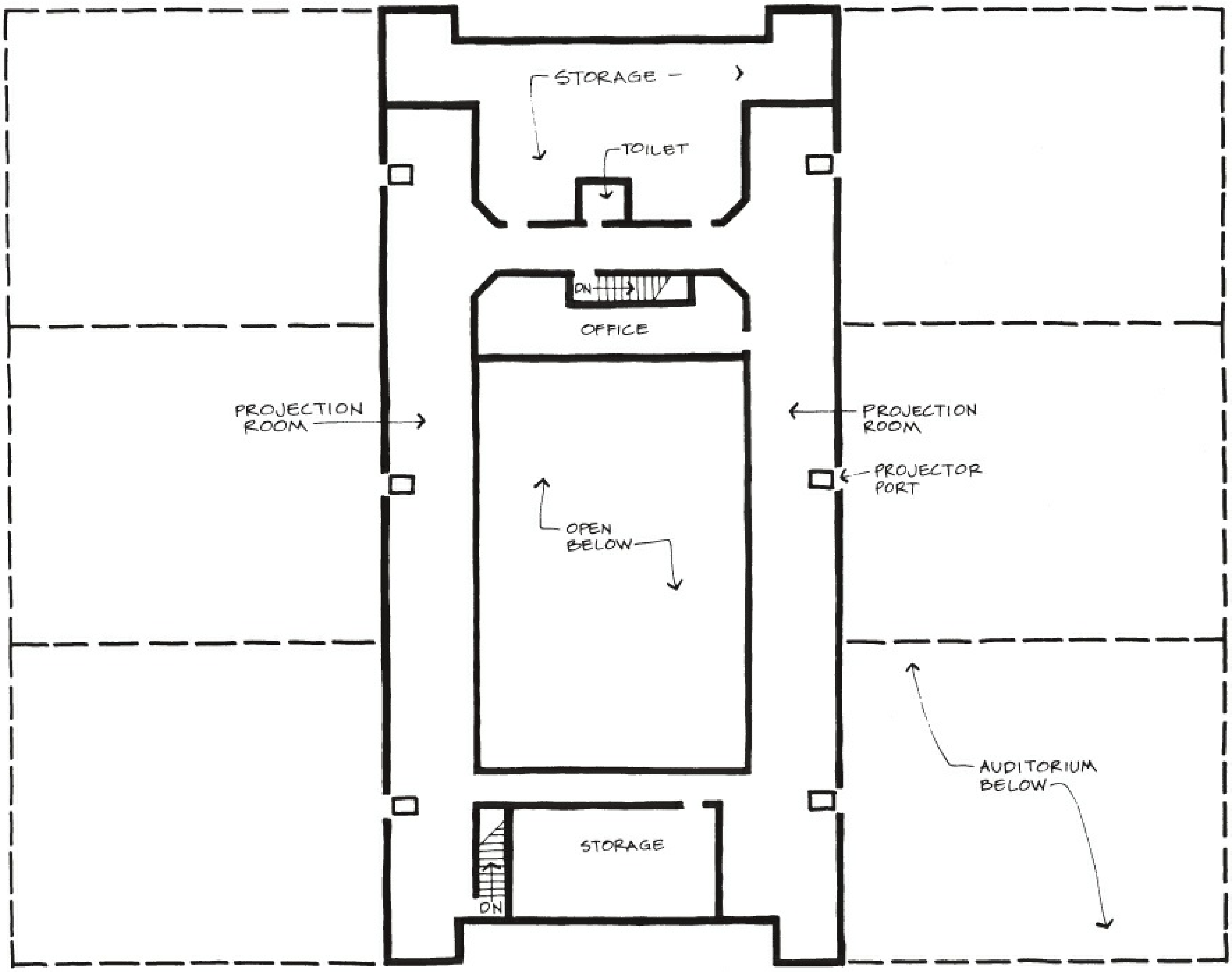


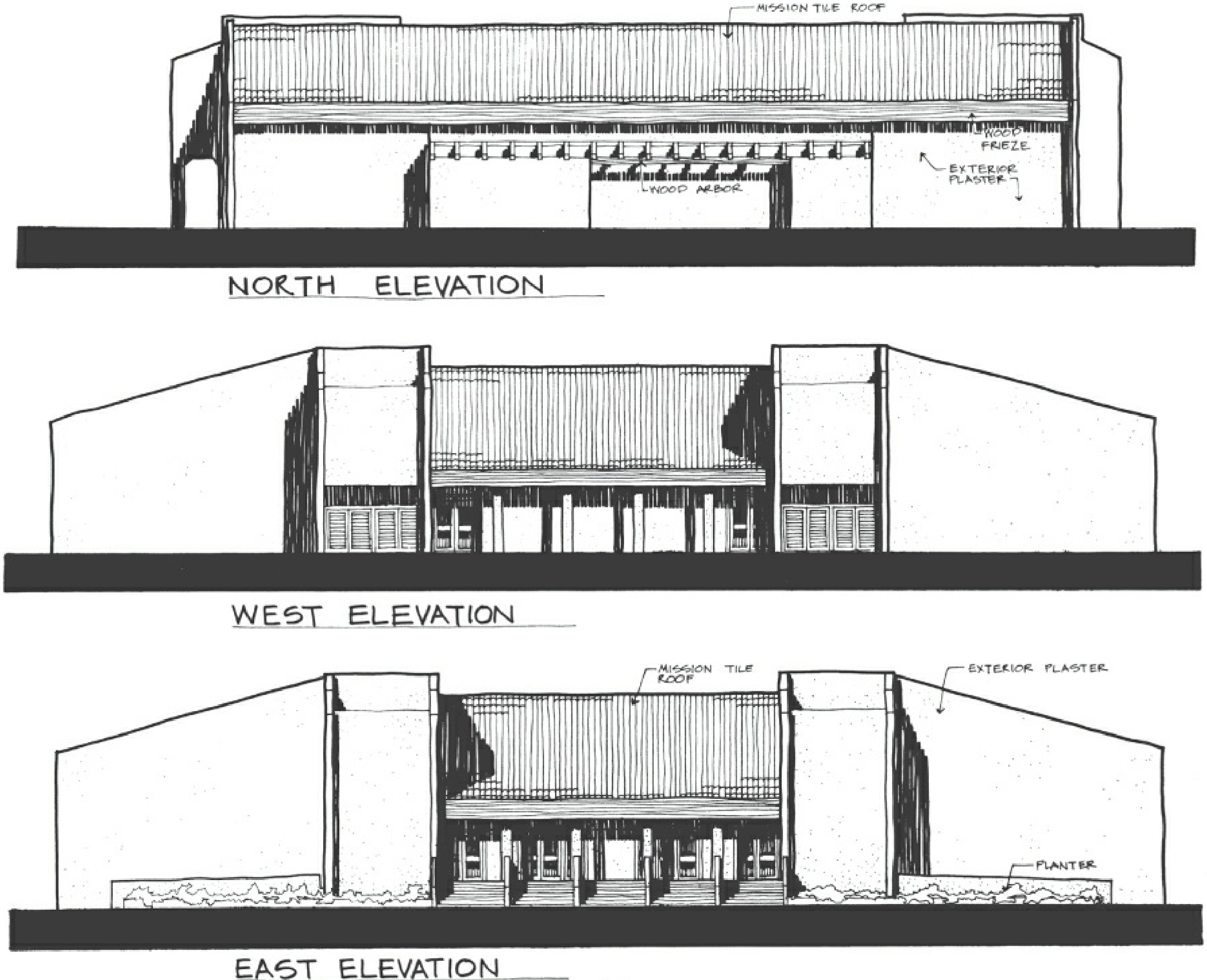
Figure 18.4 Clay Theater—preliminary upper‐floor plan.

Stage V

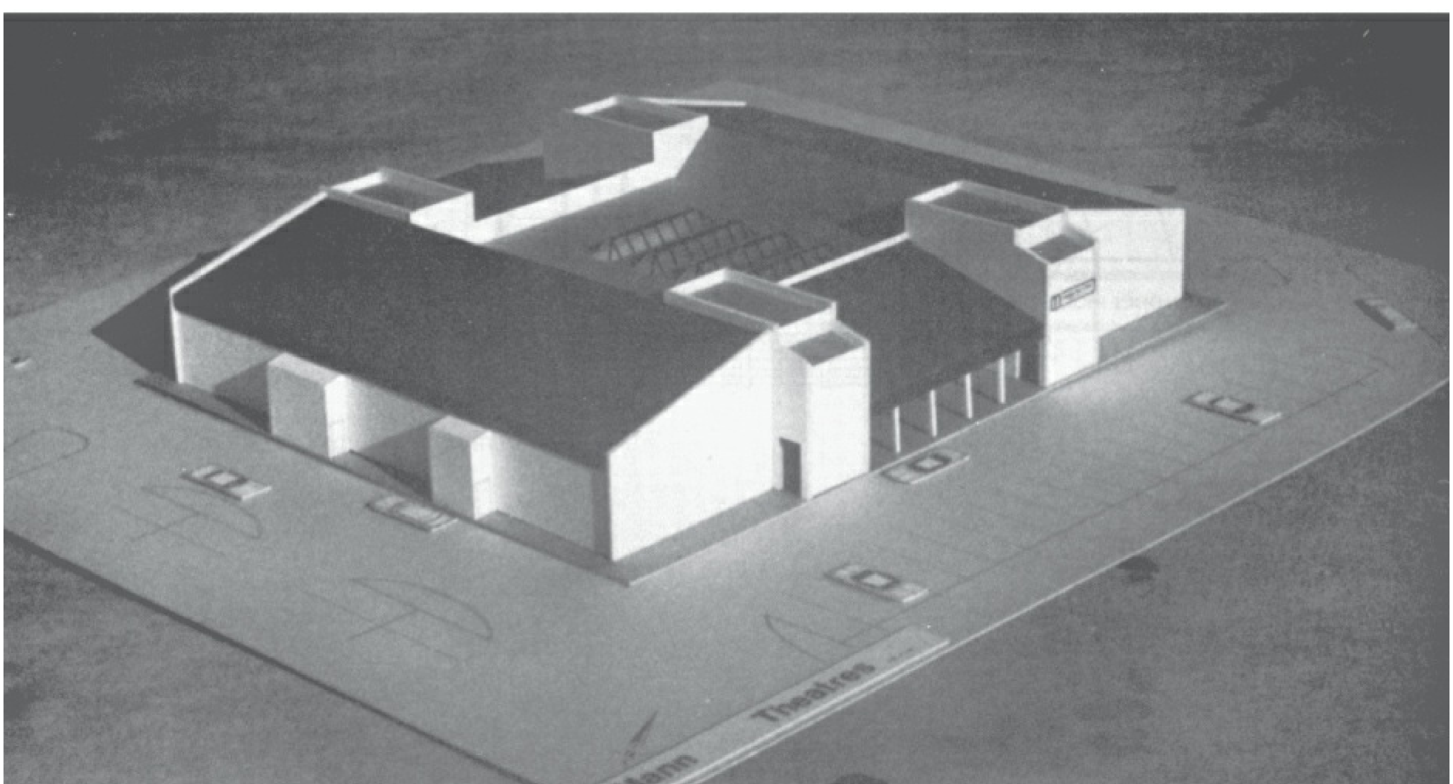
Buildings in the area where this theater is located are subject to the jurisdiction of an architectural review committee, with written criteria dictating exterior appearances and materials. One of these restrictions stated that the roof must be of mission tile with a minimum pitch of 4 in 12. Another requirement was that all roof‐mounted mechanical equipment must be shielded from view. By providing the required sloping roof planes over the auditoriums and the rear and front lobby access, we created a well that would screen the roof‐mounted heating and ventilating equipment.

For aesthetic reasons, we decided to soften the facade of the building by breaking up the long exterior blank walls at the rear of the auditoriums. We added a heavy timber arbor to provide shadows on the blank walls. See Figure 18.5A. The arbor stain and general design were chosen to be compatible with the mission tile. To provide an acceptable finish, we covered the concrete block with a plaster finish. To enhance the exterior and further

define the design elements, as well as to fulfill building department requirements, we added concrete columns in the colonnade. Instead of using three…dimensional drawings for presentation, a conceptual model was constructed, defining the general massing of the building as well as major architectural features. This model is shown in Figure 18.5B. An aerial photo of the completed site is shown in Figure 18.6.


MISSION TILE ROOF
WOOD FRIEZE
EXTERIOR PLASTER
WOOD ARBOR
NORTH ELEVATION
WEST ELEVATION
MISSION TILE ROOF
EXTERIOR PLASTER
PLANTER
EAST ELEVATION

Ⓐ


Mann Theatres

Ⓑ

Figure 18.5 Clay Theater—A. Preliminary exterior elevations. B. Conceptual model.

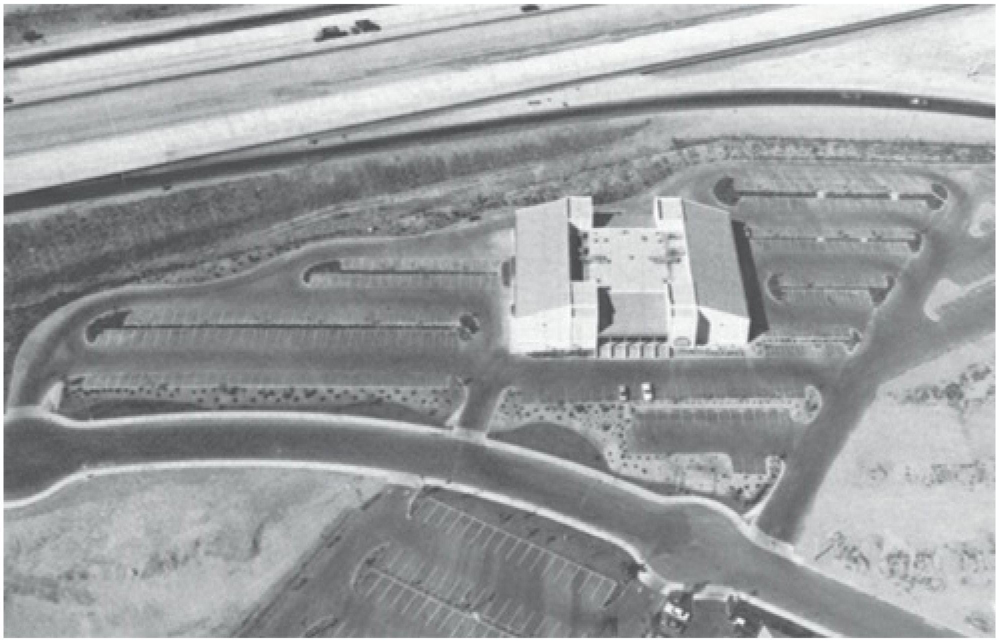
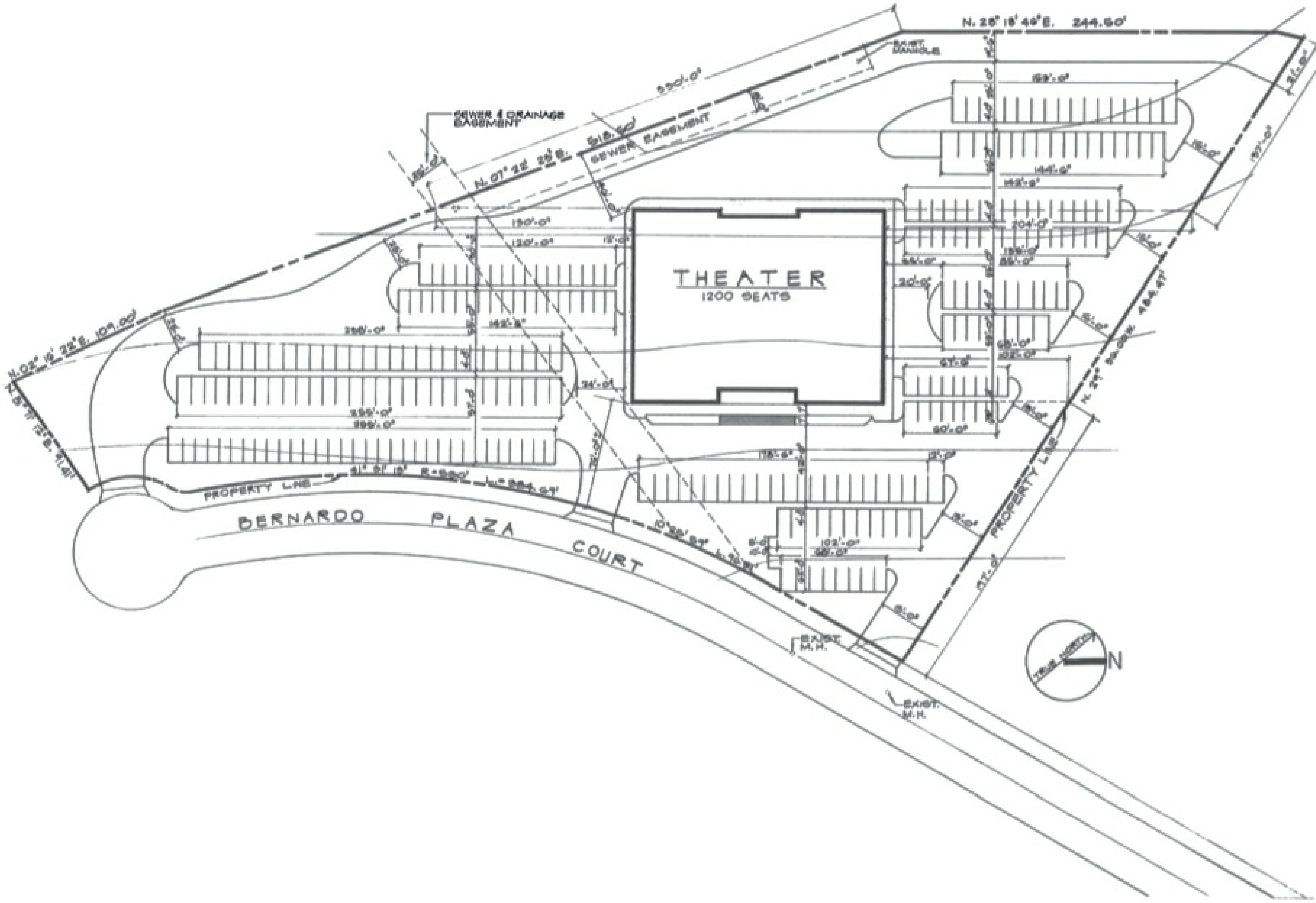


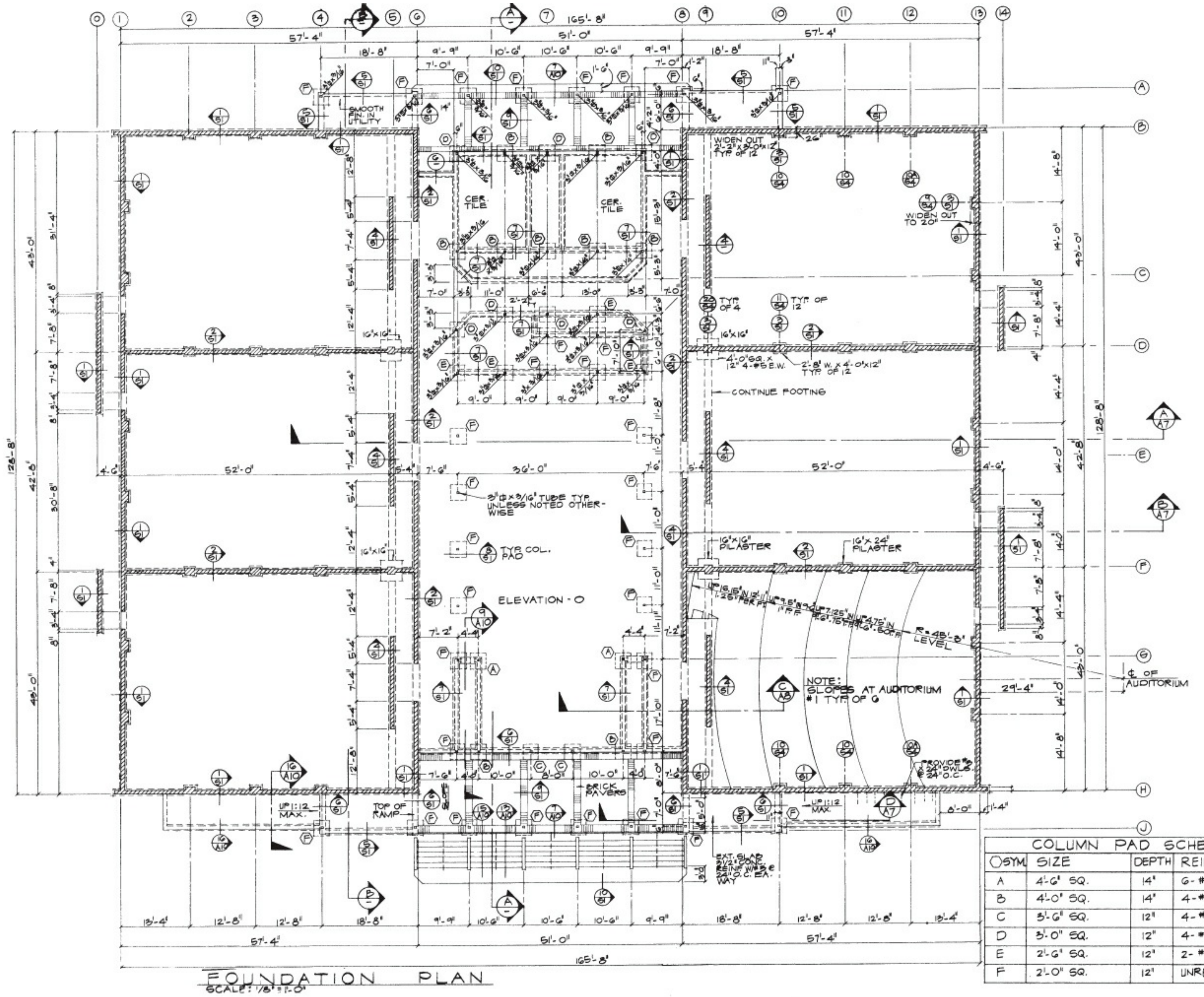
Figure 18.6 Aerial photo of finished site.

(Courtesy of William Boggs Aerial Photography. Reprinted with permission.)

The various stages of the working drawings can be found in Chapters 7 through 11. In this portion of the text you will only find the last stage of the working drawings. Check Figure 18.7 for the final stage of the site plan working drawing, and Figure 18.8, which shows a portion of the grading plan to reveal water flow control. See Figures 18.9 through 18.15 for final stages of the working drawings.



[**Figure 18.7**]() Clay Theater—final stage of site plan.



COLUMN PAD SCHEDULE			
SYM	SIZE	DEPTH	REINFORCING
A	4'-6" SQ.	14"	6-#5 BARS EA. WAY
B	4'-0" SQ.	14"	4-#5 E.W.
C	3'-6" SQ.	12"	4-#5 E.W.
D	3'-0" SQ.	12"	4-#4 E.W.
E	2'-6" SQ.	12"	2-#4 E.W.
F	2'-0" SQ.	12"	UNREINF.

Figure 18.8 Enlargement of site/grading plan to reveal water flow control detail.

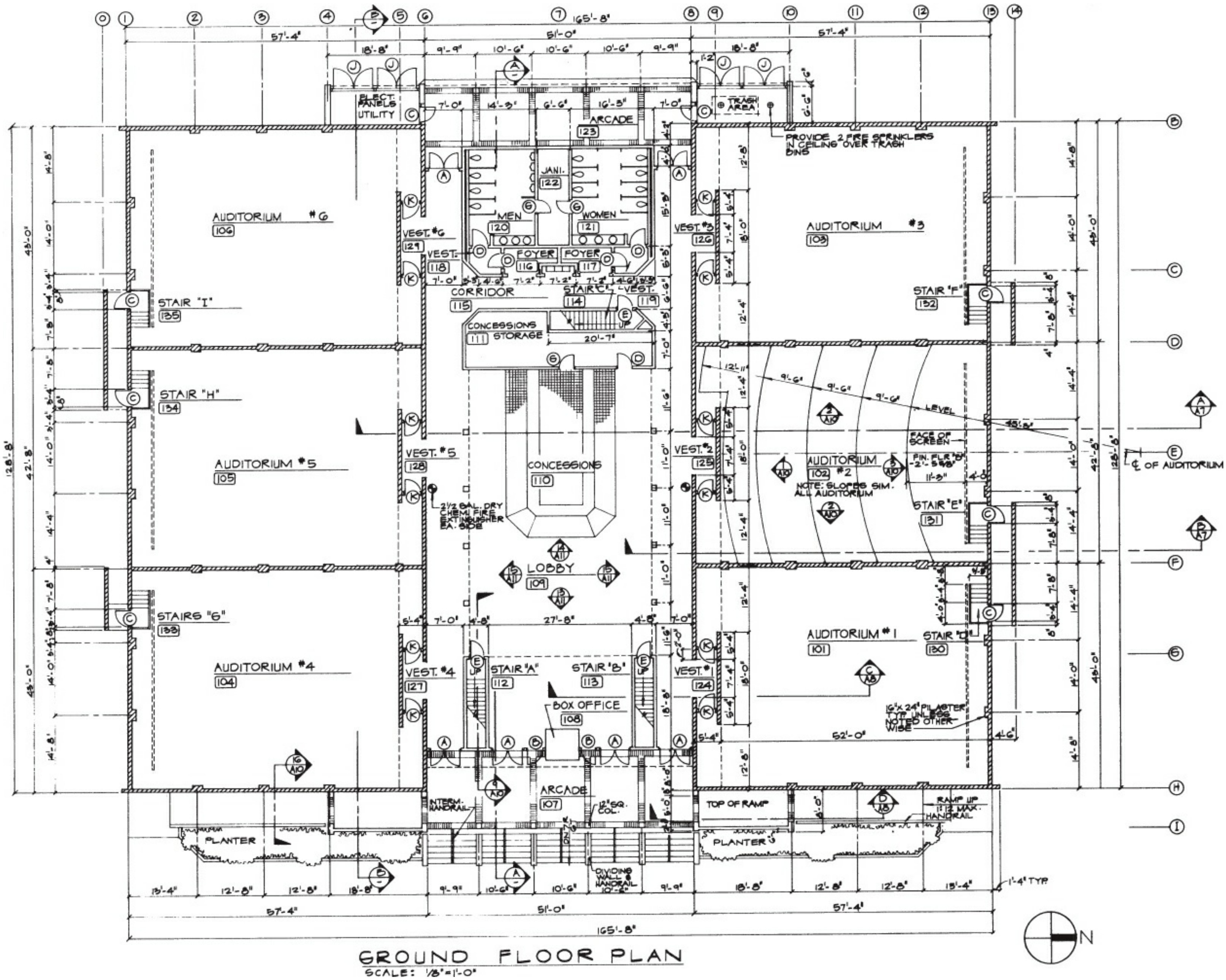


Figure 18.9 Final…stage working drawing—foundation plan.

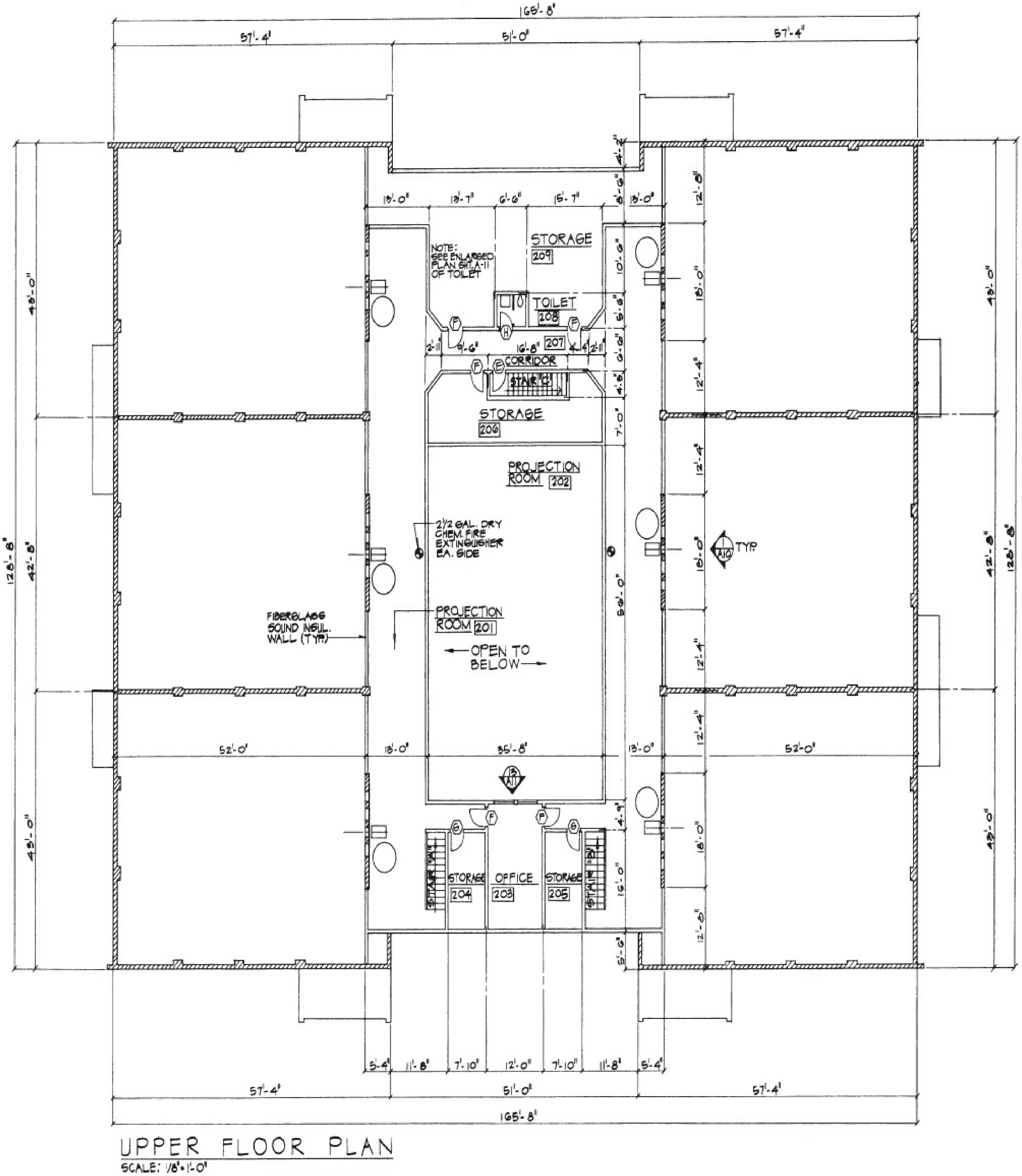


Figure 18.10 Final…stage working drawing—ground…floor plan, or elevations.

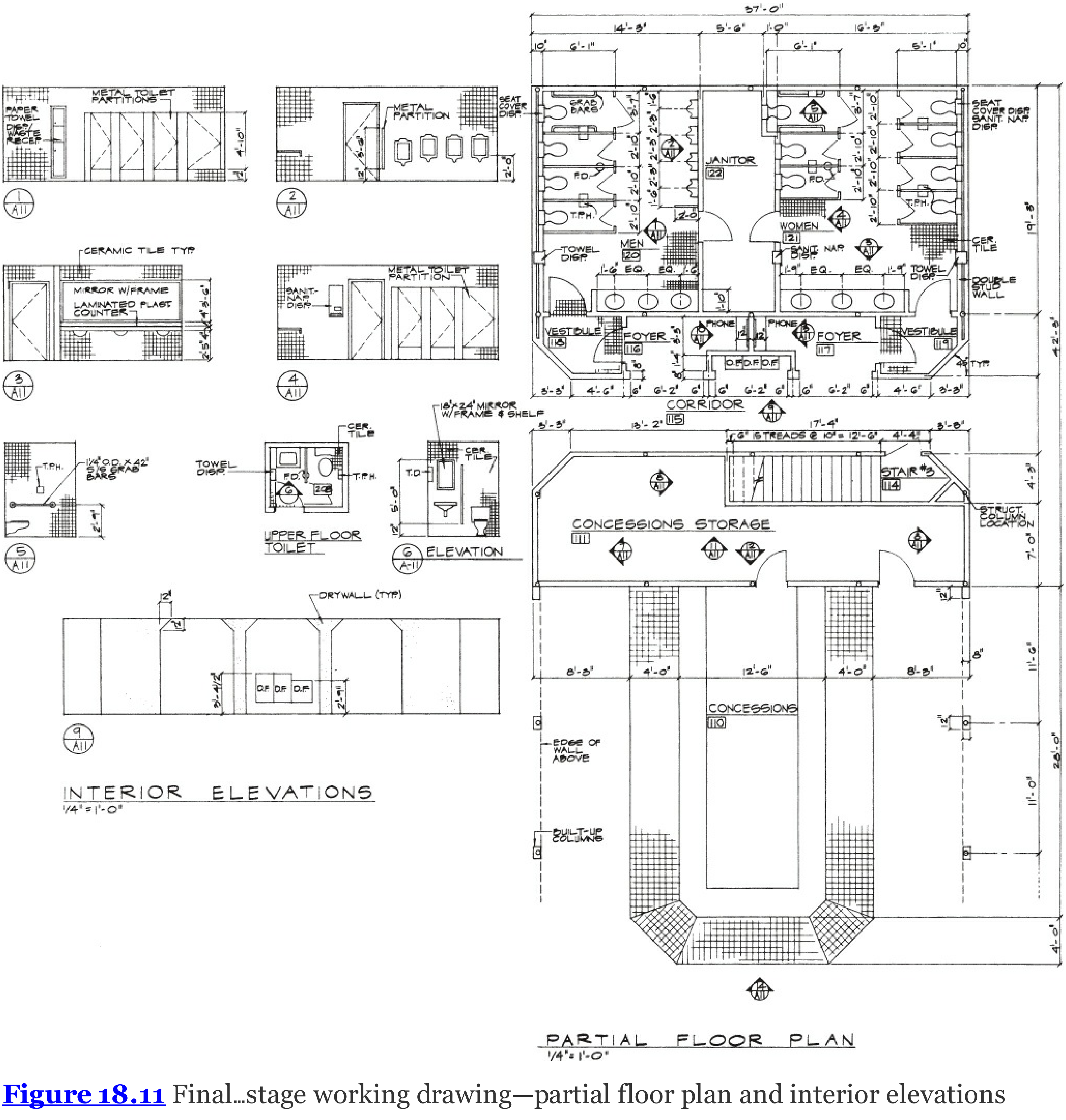


Figure 18.11 Final‥stage working drawing—partial floor plan and interior elevations

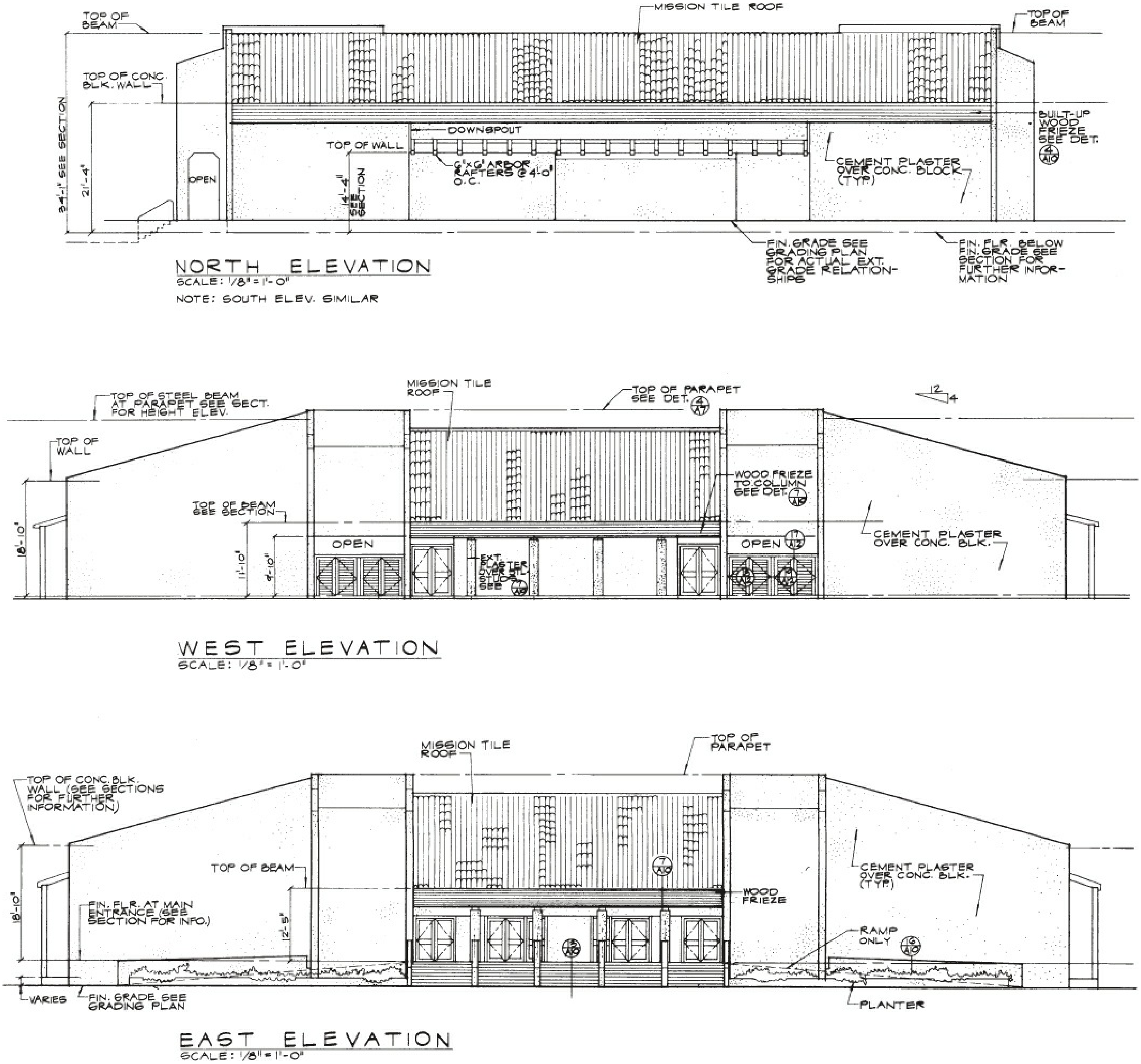


Figure 18.12 Final…stage working drawing—exterior elevations.

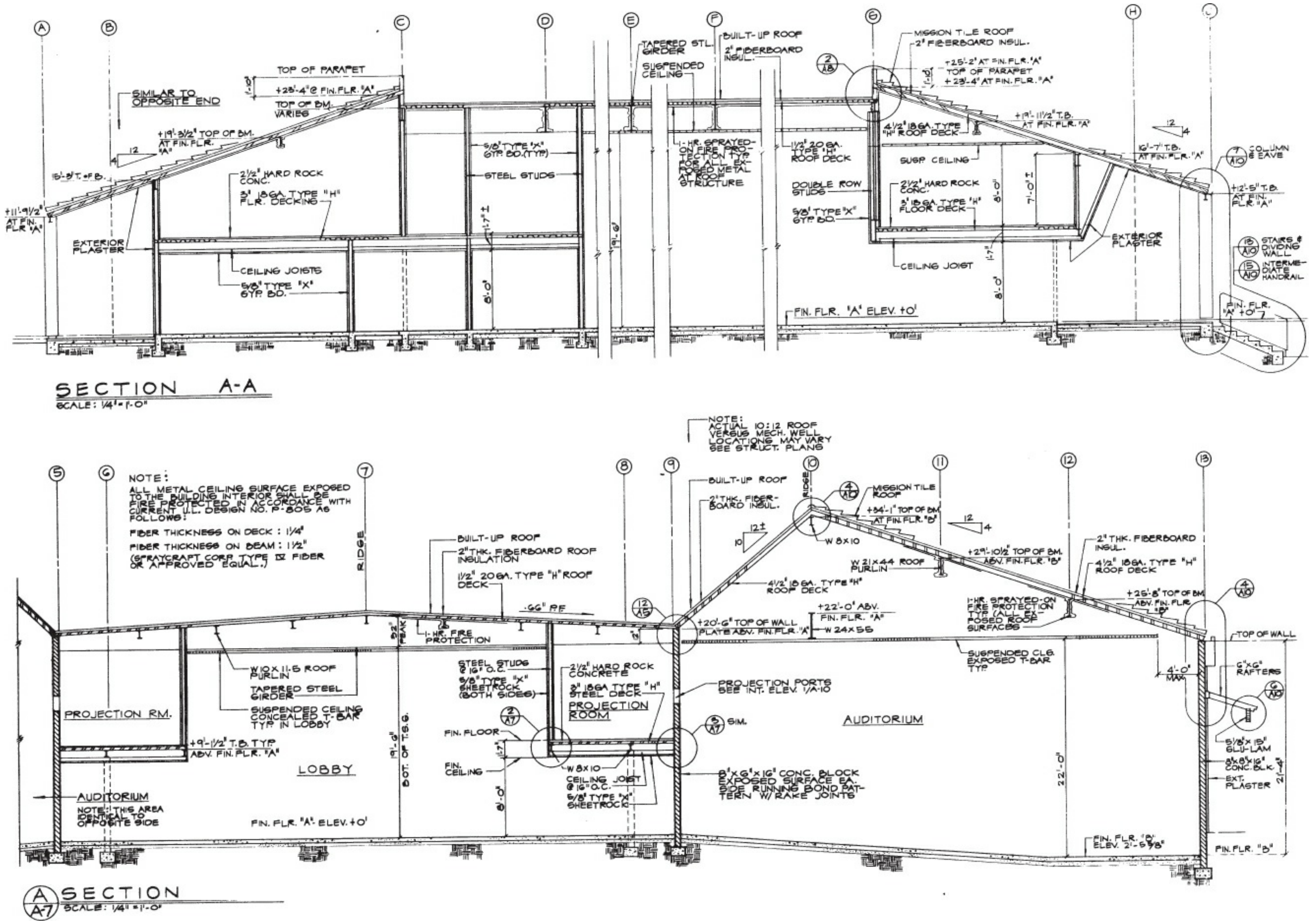


Figure 18.13 Final…stage working drawing—building sections

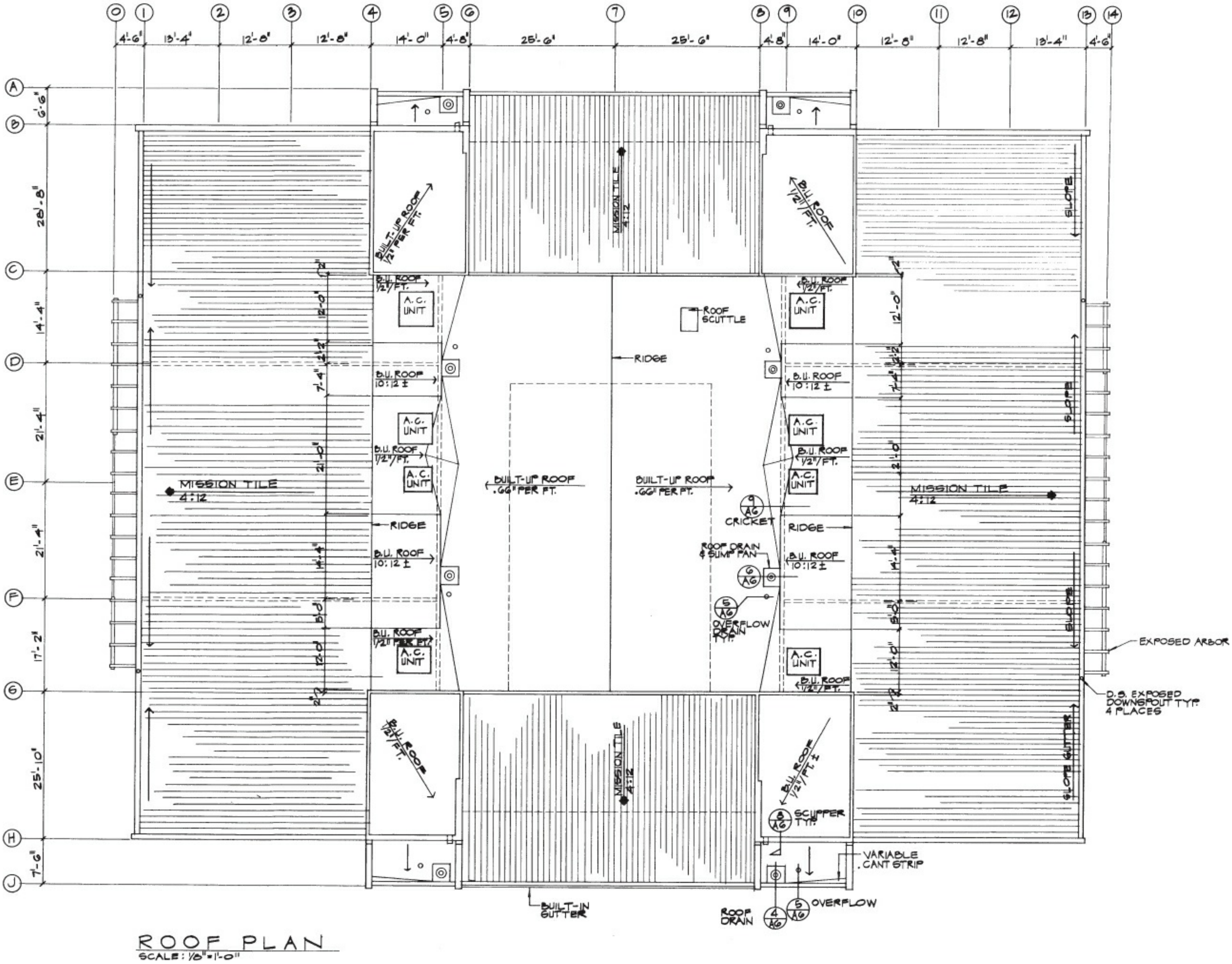


Figure 18.14 Final…stage working drawing—roof plan.

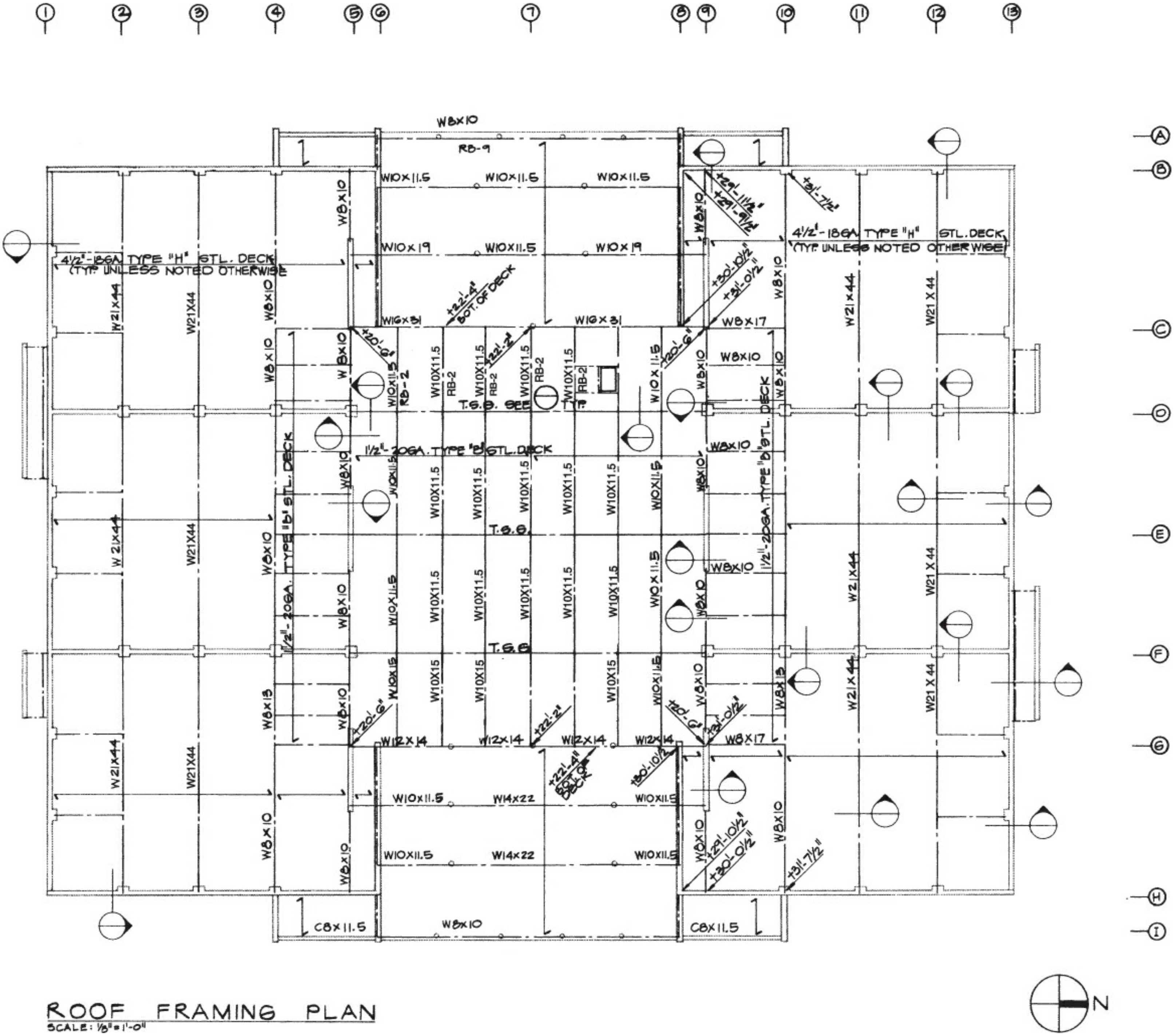


Figure 18.15 Final…stage working drawing—roof framing plan.

MARGAUX—MASONRY BUILDING

The masonry building is an existing building that is being renovated. Masonry has many advantages, one of which is strength to apply a new skin to significantly change the image of the building. See Figures 18.16 through 18.23.

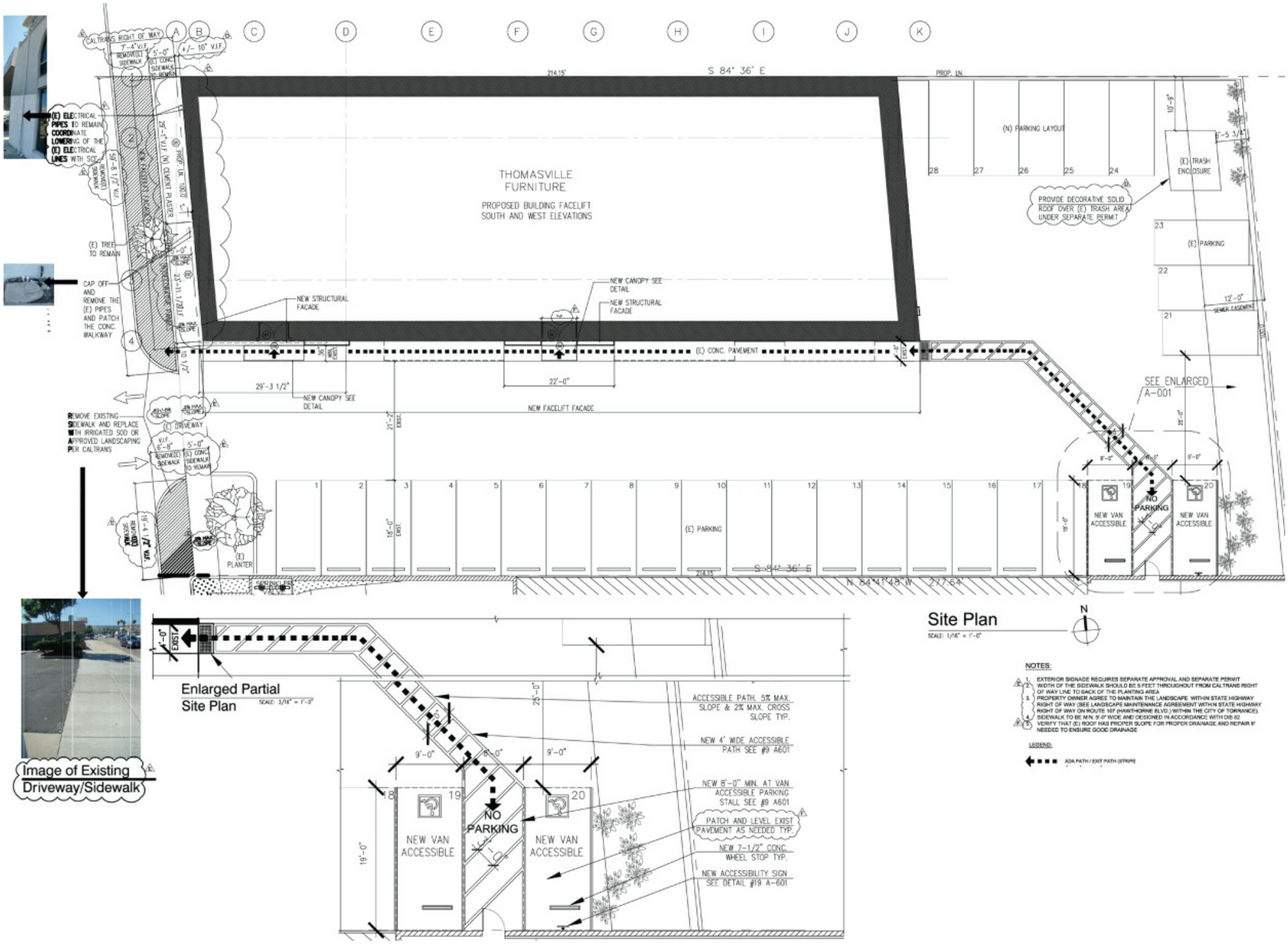


Figure 18.16 Site plan for the Margaux masonry building.

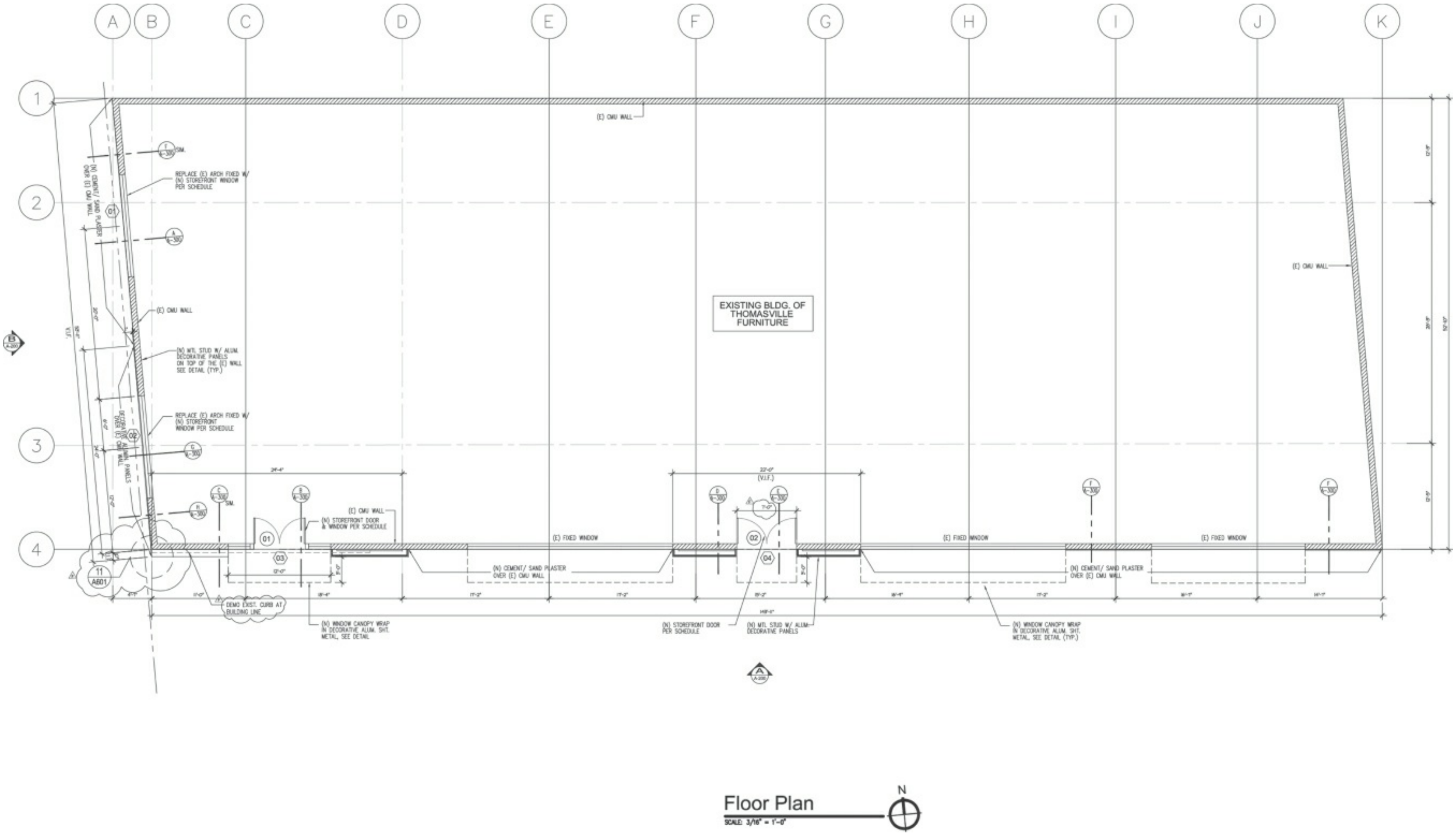


Figure 18.17 Floor plan.

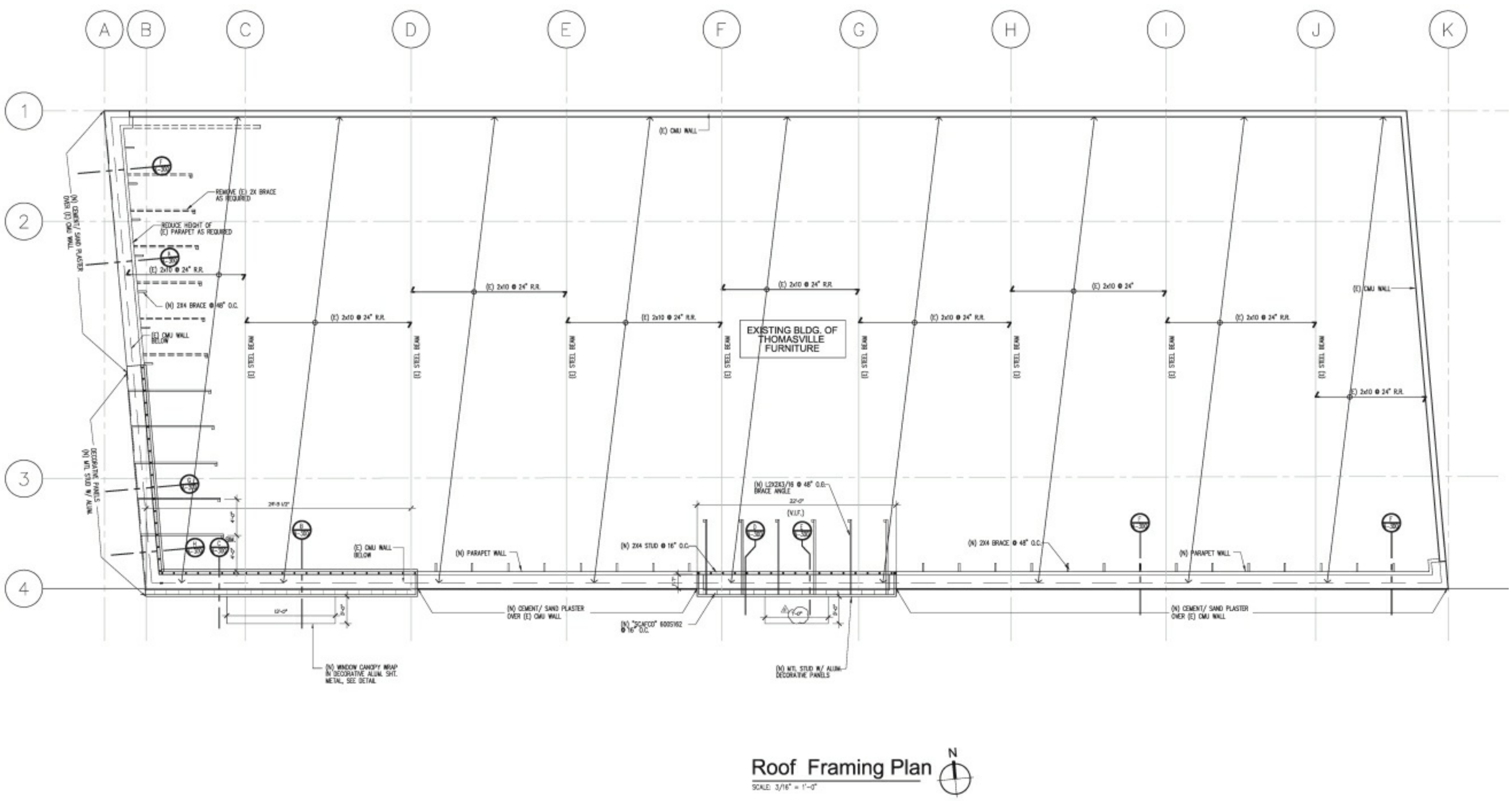
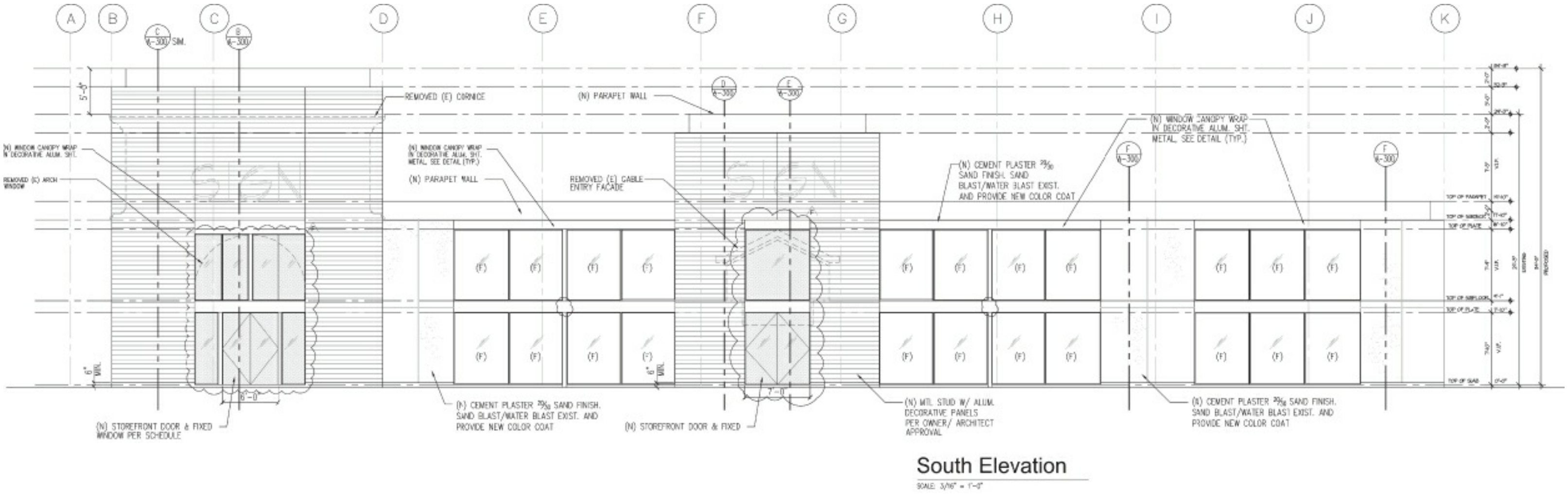


Figure 18.18 Roof framing plan.



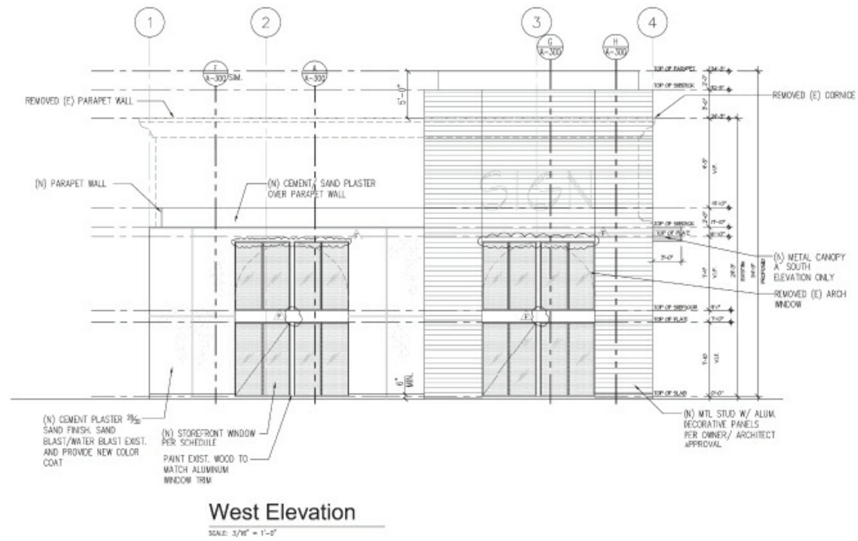


Figure 18.19 Elevations.

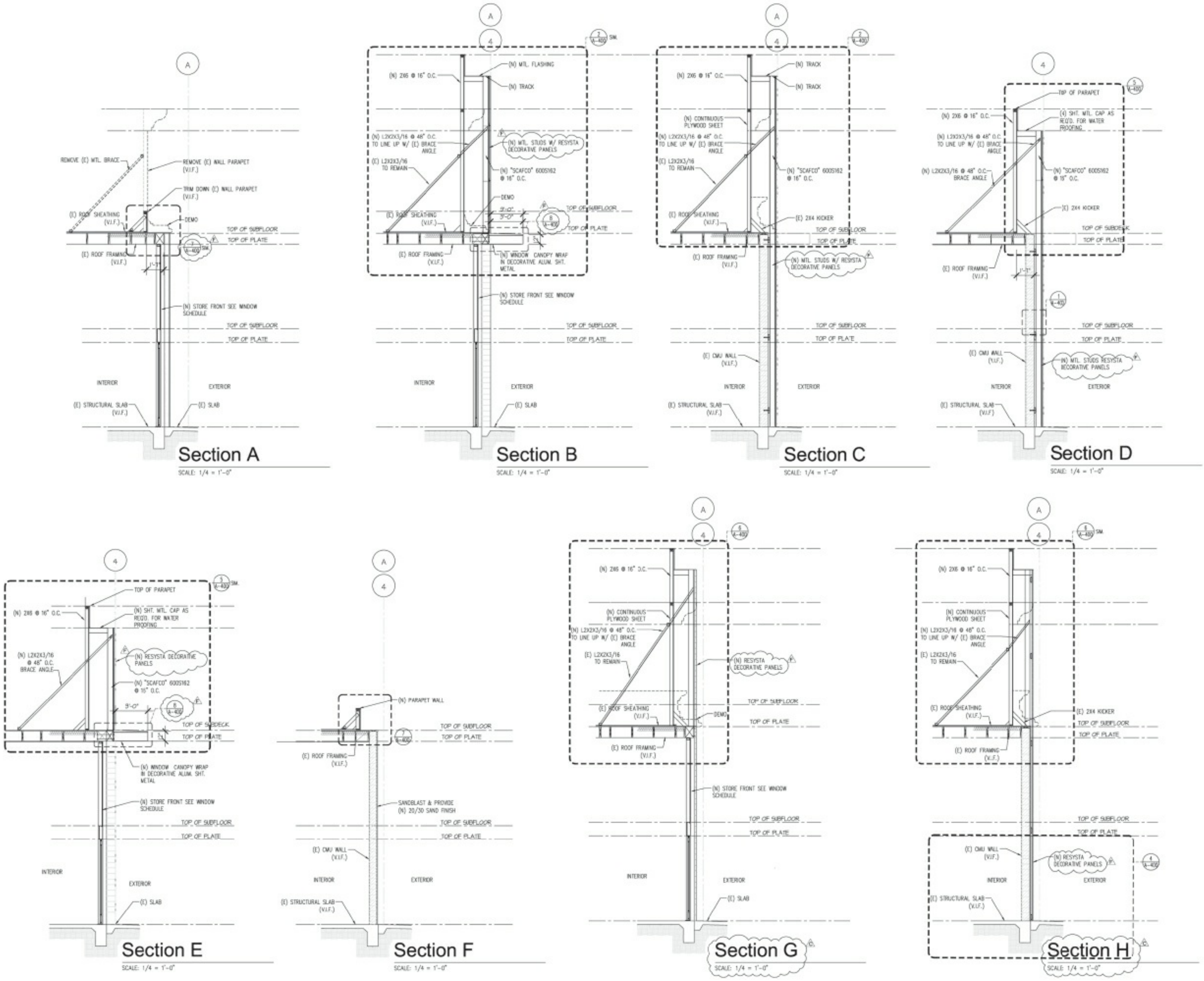


Figure 18.20 Partial sections.

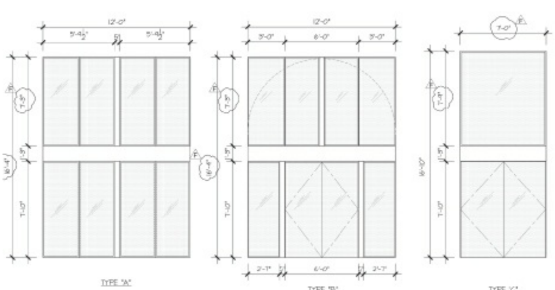
Window Schedule

Key	Width	Height	Type	Material	Glazing	Head Ht. From F.F.	Remarks
01	12'-0"	16'-4"	A	ALUMINUM	TEMPERED	7'-5" AND 16'-4"	WINDOW WALL
02	12'-0"	16'-4"	A	ALUMINUM	TEMPERED	7'-5" AND 16'-4"	WINDOW WALL
03	12'-0"	16'-4"	B	ALUMINUM	TEMPERED	7'-3" AND 16'-4"	WINDOW WALL
04	7'-0"	16'-10"	C	ALUMINUM	TEMPERED	7'-10" AND 16'-10"	WINDOW WALL

Door Schedule

Key	Width	Height	Thickness	Type	Material	Glazing	Rating	Hardware	Remarks
01	6'-0"	7'-10"	1 1/4"	A	ALUMINUM	TEMP.		-	WINDOW WALL ENTRANCE SEE WINDOW TYPE "D", AUTOMATIC EXIT & OPEN DURING BUSINESS HOURS
02	7'-0"	7'-10"	1 1/4"	A	ALUMINUM	TEMP.		-	EXISTING DOOR TO BE REUSED WINDOW WALL ENTRANCE SEE WINDOW TYPE "C", AUTOMATIC EXIT & OPEN DURING BUSINESS HOURS

WINDOW TYPES



DOOR TYPES

TYPE "A"

WINDOW NOTES:

1. ALL EXPOSED ALUMINUM TO BE CLEAR ANODIZED.
2. ALUMINUM SECTIONS SHALL BE SIZED TO ACCOMMODATE WIND LOADS PER CODE.
3. ALL GLAZING @ HAZARDOUS LOCATIONS INCLUDING DOORS & ADJACENT SIDELITES WITHIN 24" SHALL BE SAFETY GLAZING COMPLYING w/ CBC STANDARD 24-2, PART I.
4. FLASH, SEAL AND CAULK PER MANUFACTURERS SPECIFICATIONS.
5. ALL STOREFRONT GLAZING SHALL HAVE A PERMANENT LABEL INDICATING THE U VALUE (U-0.75 MIN.) AND THE SOLAR HEAT GAIN COEFFICIENT (SHGC-0.54 MIN.) USED FOR THOSE INSTALLATIONS. LABELS SHALL BE VISIBLE WHEN GLAZED.

DOOR NOTES:

1. BOTTOM OF INTERIOR DOORS TO BE 3/8" ABOVE FINISH FLOOR.
2. ALL EXPOSED ALUMINUM TO BE CLEAR ANODIZED.
3. ALUMINUM SECTIONS SHALL BE SIZED TO ACCOMMODATE WIND LOADS PER CODE.
4. ALL GLAZING IN DOORS TO BE TEMPERED.
5. FLASH SEAL AND CAULK PER MANUFACTURERS SPECIFICATIONS.
6. MAXIMUM EFFORT TO OPERATE DOORS SHALL NOT EXCEED 8.5# FOR EXTERIOR DOORS, 5# FOR INTERIOR DOORS AND 15# FOR FIRE DOORS.
7. BOTTOM 10" OF ALL DOORS SHALL HAVE A SMOOTH UNINTERRUPTED SURFACE.
8. MAXIMUM HEIGHT OF THRESHOLDS TO BE 1/2" MAXIMUM VERTICAL DISTANCES ABOVE ADJACENT FLOOR LEVEL. EXPOSED EDGES OF THRESHOLDS SHALL BE BEVELED TO AN ANGLE NOT TO EXCEED 45 DEGREES SO THAT NO VERTICAL CHANGE EXCEEDS 1/4".
9. HAND ACTIVATED DOOR OPENING HARDWARE TO BE 30" TO 44" ABOVE FLOOR AND BE OPERABLE WITH A SINGLE EFFORT BY LEVER TYPE HARDWARE.
10. EXCEPT FOR MAIN EXTERIOR ENTRY DOORS (@ LOBBIES ONLY) WITH WARNING SIGNAGE, ANY LOCKS ON EXIT DOORS SHALL RELEASE BY NORMAL OPERATION FROM THE INSIDE WITHOUT KEY OR SPECIAL KNOWLEDGE OR EFFORT (LEVER HANDLES OR PANIC BARS SHALL RELEASE LOCKS).
13. PROVIDE ABOVE OR ADJACENT TO THE MAIN ENTRY DOORS STATING "THIS DOOR MUST REMAIN UNLOCKED DURING BUSINESS HOURS".
14. ALL LATCHING & LOCKING DOORS SHALL BE OPERABLE WITH A SINGLE EFFORT BY LEVER- TYPE HARDWARE, PANIC BARS, PUSH-PULL ACTIVATING BARS OR OTHER HARDWARE DESIGNED TO PROVIDE PASSAGE WITHOUT REQUIRING THE ABILITY TO GRASP THE OPENING HARDWARE.
15. ALL DOOR FRAME & HARDWARE FOR RATED DOORS SHALL BE LISTED FOR THOSE RATINGS.
16. ALL RATED ASSEMBLIES SHALL BEAR THE MANUFACTURER LABEL INDICATING THE RATING.
17. ALL HINGES @ RATED ASSEMBLIES SHALL BE BALL-BEARING OR ANTI-FRICTION.
18. ALL HOLLOW METAL DOORS TO BE 18 GAUGE MIN. GALVANIZED STEEL.
19. ALL HOLLOW METAL FRAMES TO BE 16 GAUGE MIN. GALVANIZED WELDED STEEL.
20. ALL RATED DOORS & FRAMES SHALL BEAR MANUFACTURER LABELS INDICATING THEIR RATING FOLLOWED BY THE LETTER "S".

Figure 18.21 Door and window schedules.

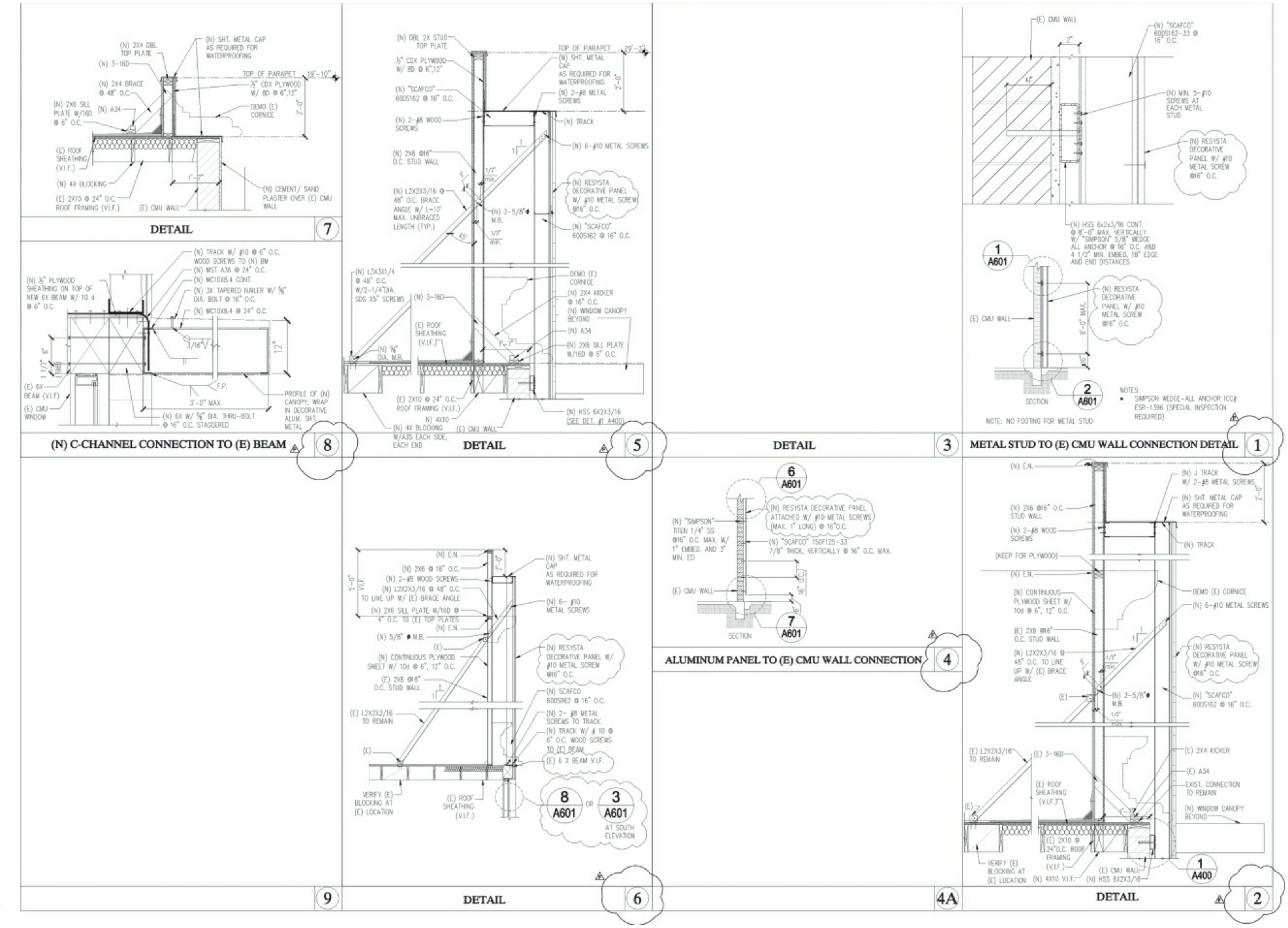


Figure 18.22 Details.

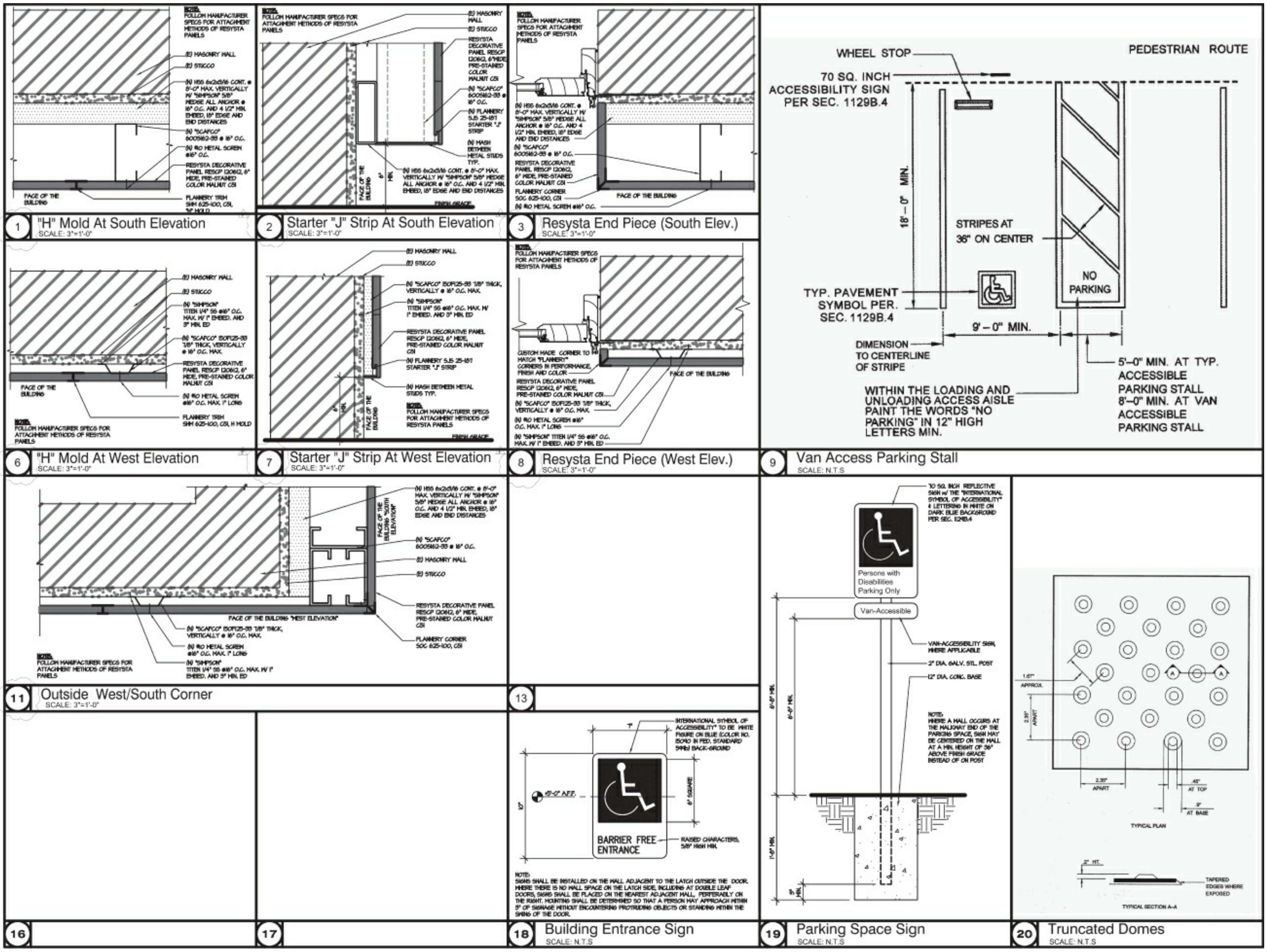


Figure 18.23 Details.

Index

WILEY END USER LICENSE AGREEMENT

THE PROFESSIONAL PRACTICE OF
ARCHITECTURAL WORKING DRAWINGS

OSAMU A. WAKITA · NAGY R. BAKHOUM · RICHARD M. LINDE

FIFTH EDITION

WILEY